ILLUMINATING ENGINEERING

MARCH, 1950

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I.E.S. Recommended Practice of Library Lighting
Color Preference Studies with Fluorescent Lamps
Low Temperature Performance with Krypton
Fluorescent Lighting for a Spray Booth
Utilization Curves for Floodlights
Supplementary Lighting Techniques
Fading of Colored Materials

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

CONTENTS: ● Fundamentals and Benefits of Planned Lighting ● How to Appraise Lighting Equipment ● How to Analyze the Seeing Task Table of Recommended Footcandle Values ● How to Select one of the 12 Lighting Systems ● How to Locate Lighting Units ● Lighting Layout Suggestions ● "Short-Cut" Tables of Footcandles Obtained ● Selection of Special Service and Supplementary Units.

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Fading of Colored Materials by Light and Radiant Energy

By A. H. TAYLOR and W. C. PRACEJUS

LIGHT IS an indispensable factor in the display and sale of merchandise, but long exposures to high intensities of illumination may result in damage to the articles displayed. Consequently, a knowledge of some of the complex facts about the fading of colored goods by radiant energy, both visible and invisible, should be of value to merchants in reducing preventable losses.

Wavelength is one of the most important factors in making radiant energy visible to the human eye. It is also important in the potentiality of energy to produce fading of colored materials and deterioration of other materials, but the effective spectral range is greater than that which produces vision and the wavelengths producing maximum fading may be different for every colored material. Energy must be absorbed to produce a photochemical change, but the effect is not necessarily proportional to the amount of energy absorbed. Radiant energy which is absorbed does not necessarily produce fading. Consequently, natural and artificial light-sources vary in their fading potentialities because of variations in spectral distribution of the energy radiated.

During the past 25 years Lighting Research Laboratory has prosecuted many researches for the purpose of evaluating some of the complex factors involved in fading by radiant energy. Some results have already been reported,[1-5] but other important researches have been completed recently and are being described here for the first time.

Most of the artificial sources now in use for general illumination radiate a very small percentage of their energy in the ultraviolet region, wavelengths shorter than λ4000. Measurements by the authors gave the following values for natural daylight and for several common illuminants:

Energy shorter than λ4000

Illuminant	Microwatts per lumen
Midsummer sunlight and skylight	720
500-watt tungsten filament lamps	78
3500° white fluorescent lamps	53
4500° white fluorescent lamps	72
Daylight fluorescent lamps	93
Soft white fluorescent lamps	63

MESSRS. TAYLOR AND PRACEJUS are physicists with the Lighting Research Laboratory, General Electric Co., Nela Park, Cleveland, Ohio.

Ultraviolet energy is often blamed for much of the fading of colored textiles by light. Some have gone so far as to claim that complete protection from fading by fluorescent lamps can be achieved by using plastic sleeves on the lamps, these sleeves being claimed to be opaque to the ultraviolet. The above table shows that there is very little ultraviolet in the radiation from the lamps hence its complete absorption should change very little the fading produced by the same number of footcandle-hours' exposure with and without absorption of the ultraviolet. This has been confirmed by tests with 29 colored textiles exposed to shielded and unshielded fluorescent lamps.

Since natural daylight contains about ten times as much ultraviolet per lumen or footcandle as does the light from artificial illuminants (see Table above), it appeared of interest to determine whether fading in daylight would be greatly reduced by filtering out this energy. In previous papers[3, 4] it has been shown that fading of colored textiles is produced by energy throughout the ultraviolet and visible spectrum up to approximately λ5800, the orange-red.

In a test just completed, 84 colored textile specimens were exposed to midsummer sunlight and skylight through ¼-inch plate glass (which transmits most of the ultraviolet in sunlight) to simulate conditions in a show-window with daylight. One portion of each specimen was covered with a Wratten 2A gelatin filter which absorbs the ultraviolet shorter than λ4000 but freely transmits energy in the visible spectrum. For comparative purposes another portion of each specimen was covered with cellophane which freely transmitted the ultraviolet and visible energy. Some of the specimens were exposed for a total of 194,000 footcandle-hours, others which faded sooner being given a shorter exposure. Fifty-seven of the specimens (68 per cent) faded as much under the Wratten 2A filter (no ultraviolet) as did those under the cellophane (ultraviolet plus light). Twenty-four of the specimens (29 per cent) showed slightly greater fading with ultraviolet plus light than without ultraviolet, though in no case was there a significant difference. *These results indicate that the fading of colored textiles by daylight is principally due to radiant*

energy in the visible spectrum. Any filter which appreciably reduces the fading must greatly reduce the energy in the violet, blue, green, and yellow portions of the spectrum, hence will greatly alter the colored appearance of the objects illuminated through it.

From our extensive researches on fading, certain generalities representing average results may be stated. Doubtless there are exceptions to each of these, but they may serve as a basis for precautions in the use of light in order to reduce damage to merchandise. These generalizations are as follows:

1. The reciprocity law applies over a practical range of artificial illumination. *On the average*, the fading produced by a single type of light source appears to be approximately constant for a definite exposure in footcandle-hours, when these two factors, footcandles and time, are varied individually but their product is kept constant. Tests with tungsten filament lamps at 50, 500 and 2700 footcandles furnish the basis for this conclusion.

2. Since fading is a photochemical reaction and oxygen is necessary, fading is greatly reduced when the specimen is in an evacuated enclosure.

3. Humidity throughout a wide range does not appreciably affect the rate of fading, but texture of the material may be modified at very high humidity.

4. Temperature does not appreciably influence rate of fading at temperatures of 85 to 120° F., but at 150° the fading proceeds appreciably faster than at 85°; in fact the rate is approximately doubled.

5. Fading is produced by radiation throughout the ultraviolet and visible regions up to approximately λ5800, the orange-red. Filtering out the ultraviolet in daylight, wavelengths shorter than λ4000, does not appreciably reduce the rate of fading.

6. Different illuminants vary in their fading power. Relative *exposures in footcandle-hours* to produce equal fading with four illuminants have the following approximate ratios:

Midsummer sunlight plus skylight	1.0
North skylight	0.5
Tungsten filament lamps (500-watt)	1.8
Fluorescent daylight lamps	1.7

7. The exposure in footcandle-hours necessary to produce a just noticeable change in color depends on the fastness of the dyes used. For the materials used in our tests, an exposure of 50,000 footcandle-hours from tungsten-filament or fluorescent lamps produced a perceptible color change in half the specimens.

There are other merchandising fields besides textiles where fading or color change produced by light may cause economic losses. Two of these, meats and cigars, displayed in illuminated cases have been studied recently in our laboratories, with results which are of considerable interest.

In meat display cases either tungsten-filament or fluorescent lamps are generally used. The latter are placed inside the display case, since the heat generated is low. Tungsten lamps are usually placed outside the case, hence the light passes through at least one thickness of ¼-inch plate glass before reaching the meat. Tests with various fresh and processed meats indicate that only the processed meats such as bologna, meat loaf, boiled ham, etc., are affected by light during a normal period of display. Tests with bologna, one of the meats most susceptible to color change by light, indicate perceptible color change with an exposure of approximately 150 to 200 footcandle-hours. In a well-lighted display case this would require two to three hours. In the tests with tungsten-filament lamps of the type used with meat-display cases, a sheet of ¼-inch plate glass was interposed, to simulate service conditions. No glass was used with the soft-white fluorescent lamps.

The recording spectrophotometer was used to measure the spectral reflectance of the bologna before and at intervals during the test. Within experimental errors the fading or color change was *identical* under the two sources for *equal exposures in footcandle-hours*.

With improvements in cigar display-case lighting, involving the use of higher illumination from fluorescent lamps, the question of possible fading or bleaching of the cigars arose. The authors have just completed an extensive test to study this subject. Seven brands of cigars were displayed in a commercially-available case lighted by a 64-inch T-6 slimline fluorescent lamp. Illumination measurements at various positions on the display shelves indicated intensities ranging from 10 to 75 footcandles. Cigars were displayed in the normal manner in the case and at regular time intervals one or two cigars in each box were covered with black paper to terminate exposure to light. This gave a progressive series of *continuous* exposures ranging from two weeks to three months. At the end of this time the various exposed cigars were compared with unexposed specimens, to select those showing a just perceptible color change and those showing a change sufficiently great to be observable when comparing the exposed and unexposed areas of a single cigar, as might be done by a customer. The average exposure required to produce a just-perceptible color change was approximately 40,000 footcandle-hours. At least double this exposure was required to produce an easily noticeable change, but it is questionable whether even this amount of change would really be objectionable to most cigar smokers. These exposures are so large that it seems improbable that any objectionable changes would occur in practice, unless the cigars were located so as to receive high intensities of daylight.

For many years the National Bureau of Standards and the American Association of Textile Chemists and Colorists have cooperated in developing apparatus and techniques for determining the

color-fastness of dyed textiles. Their most recent development has been the development of dyed papers by means of which exposures in "Fadeometers" can be evaluated. The Fadeometers employ high intensity carbon arcs around which the textile specimens are rotated.

The National Bureau of Standards has been furnishing specimens of the special dyed paper, for exposure to a Fadeometer simultaneously with the test specimens. A book of standard faded papers is also furnished, by reference to which the actual exposure of the test specimens can be evaluated in "standard fading hours." The authors recently included some of these dyed papers* in their exposures of textiles to daylight in July, during which the exposures were evaluated in footcandle-hours by use of a meter previously described.[6] Using the recording spectrophotometer to compare the fading with that of specimens in two standard booklets,** it was found that one standard fading hour was equivalent to 5700 footcandle-hours of mixed sunlight and skylight in July, the paper being exposed through ¼-inch plate glass in the latter case.

Quartz mercury arcs have at times been used for accelerated fading tests. It appears probable that much of the effect is due to energy in the spectral region shorter than λ3000, energy not present in sunlight reaching the earth's surface. Another source rich in energy in this region is the germicidal lamp which radiates over 95 per cent of its ultraviolet in a single band at λ2537. This energy has been found very effective in producing fading of textiles,[5] but there is no simple relationship between the rate of fading by sunlight and by these lamps. However, our tests indicate that they can be used to advantage for qualitative tests. Textiles which will not fade with germicidal lamps have also been found to be highly resistant to sunlight.

The authors have not studied the fading of colored plastics, hence cannot state that the above generalizations apply to them. Obviously, different colorants are used and the photochemical reactions are likely to be different.

Plastics are likely to vary in regard to the depth of the penetration of ultraviolet, hence in some cases such fading as occurs may take place very near the surface. Textiles, due to their porous mesh nature, allow depth penetration of all radiations; hence the color may be altered at appreciable depths.

*Bureau of Standards Light Sensitive Paper No. 1554.
**Standard booklets No. 60 and 306.

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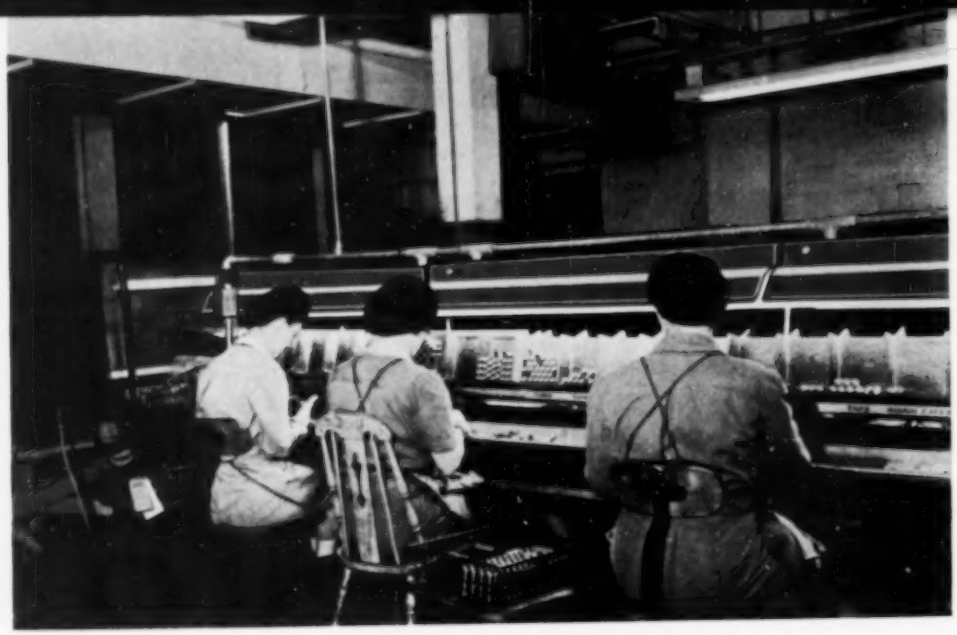
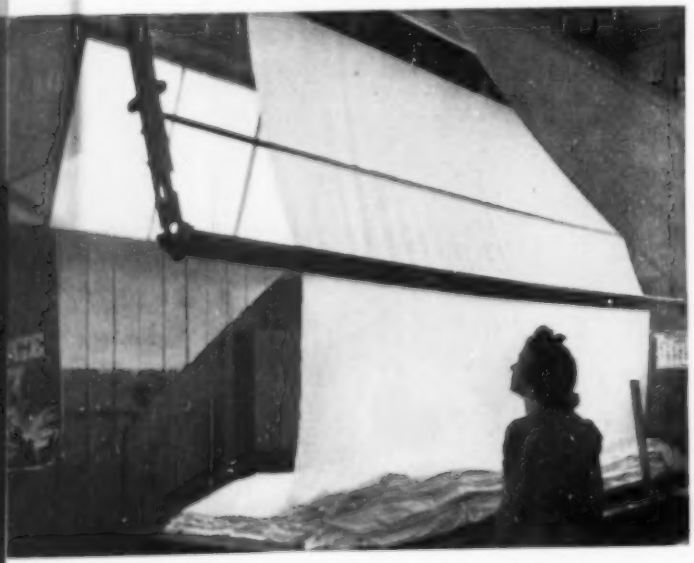
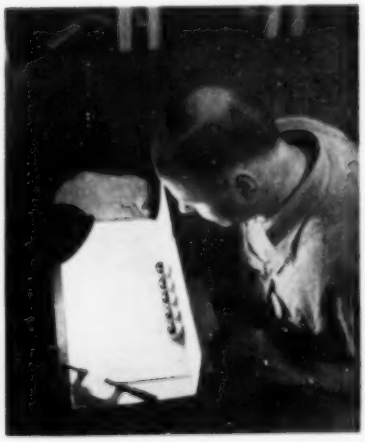
This model bowling hall was converted from a neighborhood movie. Bare fluorescent strips mounted directly on ceiling behind valances provide proper shielding to produce glareless, even illumination of 35 ft-c on the alleys. Installation at Dee's Bowling Hall, Rochester, N. Y.; Illuminating Engineer, V. D. Mitchell, Rochester Gas & Electric Co.



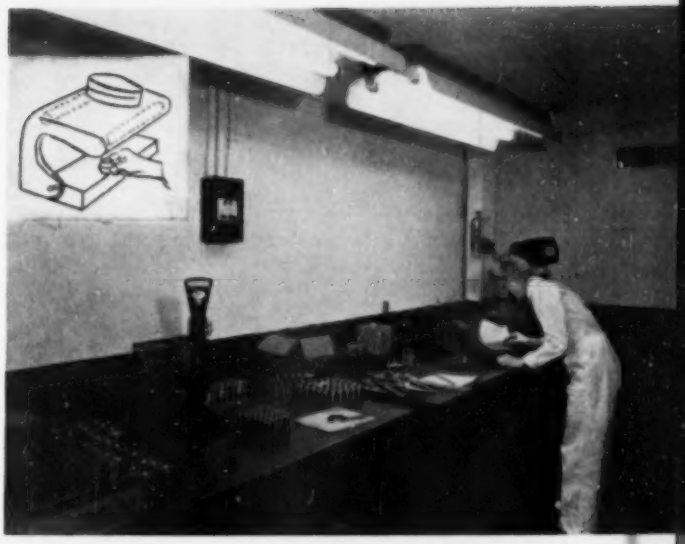
Supplementry Lighting Techniques

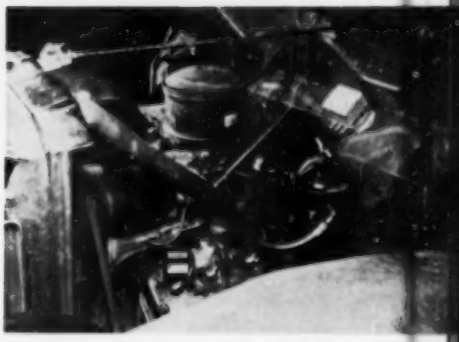
CONSIDERING the number of industrial operations requiring supplementary lighting, and the dearth of published data on it, sometimes it seems that this phase of lighting has been "Saturday's child." The I.E.S. Sub-Committee on Supplementary Lighting has been studying this subject, however. A progress report of their work was one of the features of last year's Canadian Regional Conference presented by G. F. Dean. On this and the facing page are shown examples of supplementary lighting using the techniques of: *Color* (top of page, utilizing colored light from green fluorescent lamps to emphasize contrast between rust and metal. *Contrast*—below left, the factor of contrast is used by creating a difference in brightness. Below right, chromium-plated ball bearings are inspected for defects with a minimum of eye fatigue under uniform low brightness produced by reflected light (see I.E.S. Data Sheet 38-18).





The factors of *size*, *brightness* and *contrast* (color) are used to aid seeing in the operation at right — the critical inspection of small parts. Industrial type fluorescent units are supplemented by a device employing a 5-inch magnifying lens and either two 15-watt T-type lamps or two 6-watt fluorescent lamps. In the photograph below, *adjustability* is an essential for supplementary luminaires in a garage. These 500-watt glassteel diffusers are on Trol-E-Duct for bringing the unit to where the truck is driven in. Vertical adjustment is by means of chains and hooks. The close-up view at right shows over 80 footcandles of diffused light at the motor.

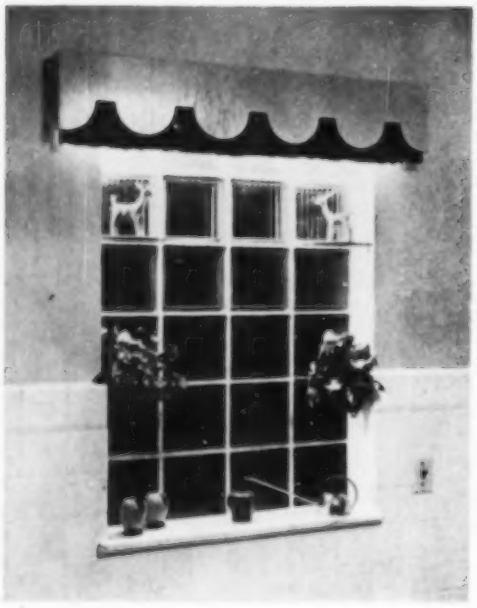




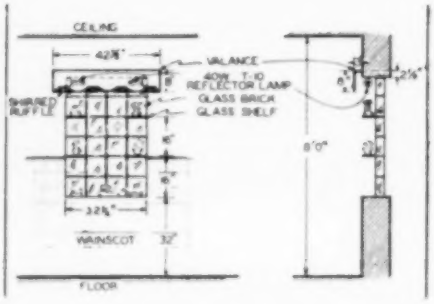
At right, the factors of *size*, *brightness* and *contrast* (color). Sodium lamps are used for microscopic inspection to detect possible flaws in small metal parts. Type NA-9 lamp, mounted on adjustable base is used at the light source.

Lighting a Glass Block Window

LIGHTING OBJECTIVE: To highlight accessories on glass shelves, at the same time providing sufficient illumination for dining.



Lighting Installation at Cincinnati, Ohio



General Information: The room is 8 feet by 9 feet in area with an 8-foot ceiling. The wainscot is white tile 48 inches high with a yellow insert stripe. Upper walls are painted soft yellow and the ceiling, white. The floor is soft yellow and red marbleized linoleum. The glass brick window is recessed approximately 5 inches.

Installation: Two T10 40-watt reflector lamps are mounted horizontally with the reflector side of the lamp at the top of the window spacing, behind a wooden valance board. (A similar lighting effect could be achieved using fluorescent lamps.) The valance is closed at the top, thus directing all the light downward. Light filters down through two glass shelves at each side of the window holding figurines and plants, giving an added decorative effect. The valance interior is painted a flat white, and the exterior a soft yellow to match the room walls. A shirred ruffle of turkey red percale is fastened in back of the valance board.

This installation provides an average illumination of 5 footcandles on a dinette table 30 inches from the window.

Lighting data submitted by Stella M. Fetzer, Cincinnati Gas and Electric Company as one solution of a lighting problem and to aid in the design of similar installations.

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Utilization Curves for Floodlights

By MERLE E. KECK

Although it is a well recognized fact that footcandle calculations for a floodlighting installation must take into consideration the loss of those beam lumens spilled outside the area to be lighted, frequently this factor is omitted due to the complication of accepted methods of calculating this loss. It is proposed to evaluate this loss of light by introducing into the conventional formula a term called "Beam Utilization." The material presented here includes a simple method of determining this "Beam Utilization" by means of Utilization Curves; as well as an analysis of the accuracy of this method of calculating footcandle levels for floodlighting installations.

CALCULATIONS of the average level of illumination for floodlighting installations are either very inaccurate or very laborious if conventional published methods are used. Average levels of illumination are nearly always calculated by the lumen method. Two basic systems of floodlighting calculations using the lumen method are generally recognized and used. The first of these is printed in the IES Lighting Handbook[1] while the second is printed in NEMA Standards[2] and is known as the "NEMA Method."

The method of calculation printed in the IES Handbook uses the basic formula:

$$\text{Number of Projectors} = \frac{E_{av} \times A}{K_m \times F_b}$$

where E_{av} = Maintained average illumination level (footcandles)

A = Area of surface to be lighted (square feet)

K_m = Maintenance Factor (usually assumed to be 0.70)

F_b = Initial lumens in the beam

This formula and method assume that all of the lumens in the beam will fall upon the area to be lighted. That this assumption is not valid is immediately apparent to anyone familiar with floodlighting installations and is shown by a scale drawing of the outline of the beam of a floodlight as it is used in a typical football field lighting installation (Fig. 1). Calculations made by this method are inherently inaccurate.

The method of calculation printed as NEMA Standard FL-6-30 is exceptionally accurate but very laborious. The method of computation consists of plotting the area to be lighted on the photometric test report and then adding up the number of lumens contained inside the plotted area. The number of lumens divided by the area in square feet gives the average intensity in footcandles. This method of calculations presupposes that the pole locations and aiming point for each floodlight are known. The plotting of the area to be lighted on the photometric curve is not difficult but takes a considerable length of time. Fig. 2 indicates the appearance of a football field when plotted on the photometric curve of a floodlight aimed as indicated in Fig. 1. This method is accurate and its use is not unduly lengthy on small jobs where only a few floodlights are required; however for sportslighting installations where 100, 200, 300 or more floodlights are involved the method is so laborious that it is seldom, if ever, used.

It is the opinion of the author that an accurate and much more usable method of calculation will result if the basic formula as printed in the IES Lighting Handbook is modified by the addition of a beam utilization factor and a voltage factor. The modified formula may be expressed as follows:

$$E_{av} = \frac{P_n \times F_b \times K_{bu} \times K_m \times K_{vf}}{A}$$

where E_{av} = Average illumination maintained in service on horizontal playing surface in footcandles

P_n = Number of projectors

F_b = Initial lumens in the beam projector

K_{bu} = Coefficient of Beam Utilization (a dimensionless ratio)

K_m = Maintenance factor; compensates for in service reduction in light output of luminaire (dimensionless ratio)

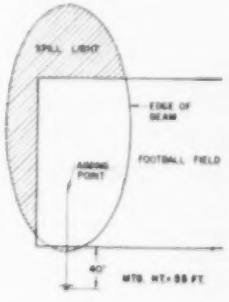


Figure 1. Outline of beam from a NEMA Type 4 floodlight (52° x 45° Beam) indicates that spill light cannot be neglected in footcandle calculations.

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Author: Westinghouse Electric Corp., Cleveland, Ohio.

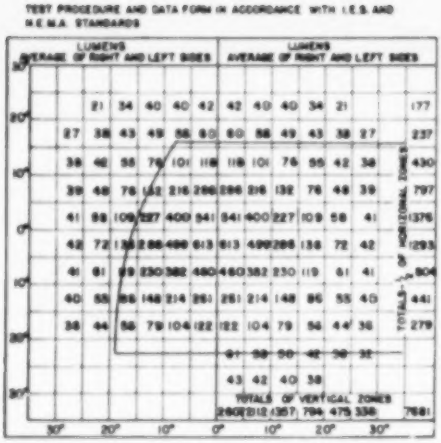


Figure 2. Plotting the outline of the field on the photometric test report permits calculation of the amount of spill light. Orientation of floodlight is that indicated in Fig. 1.

K_{vf} = Voltage factor; compensates for change in lumen output of source at other than rated voltage (dimensionless ratio)*

A = Area to be lighted (square feet)

The most important new variable introduced is the Coefficient of Beam Utilization which compensates for the fact that all of the lumens in the beam do not fall into the area to be lighted. A method of determining this factor, by using a set of utilization curves and simple ratios, has been worked out which makes the determination of the Coefficient of Beam Utilization relatively simple and easy.

Principle of Utilization Curves

The basic concept involved in the determination of utilization curves is to consider that the light which falls upon a surface normal to the floodlight beam is divided into concentric circles. Each of these circles will contain a certain percentage of the total beam lumens depending upon the distribution of light within the beam of the floodlight. Since the beam may not be symmetrical and in order to provide for instances where the beam pattern is not centered on the area to be lighted, the beam may be further divided into quarters and the percentage of light in each quarter arc calculated. This basic concept is shown in Fig. 3. From the calculations of the percentage of the beam lumens in each quarter arc, curves showing the percentage of beam lumens versus degrees from the center of the beam along Axis X and Y can be drawn. Since in photometric reports of floodlights the beam is always considered symmetrical in the right and left sides there are only three basic utilization curves.

It was believed desirable to eliminate trigonometric calculations, terms and angles from the finished curves. This was done by expressing all dimensions in terms of the mounting height. The completed utilization curves for two typical floodlights, one a narrow beam unit (NEMA Type 3) and one a wide beam unit (NEMA Type 5), are shown in Figs. 4 and 5. The method of deriving the curves is explained in Appendix I. Once such curves are calculated for a particular floodlight beam distribution, they are usable for for any application of that floodlight.

The method of determining the utilization of one floodlight from the curve is as follows. From a drawing showing the pole location, aiming point and boundaries of the area to be lighted; draw a line from the pole base through the aiming point to the far boundary. Draw a line perpendicular to the preceding line from boundary to boundary through the aiming point. Measure the distance from the pole base to the aiming point and the distances from the aiming point to the boundaries of the area to be lighted along the lines previously drawn. Dividing these distances by the mounting height provides the ratios necessary to enter the three utilization curves. After the ratios have been determined the utilization for each quarter can be determined from the applicable curve. Adding the utilizations for each quarter yields the total utilization for the floodlight.

To determine the utilization for a complete installation, it is necessary to average the utilizations for all individual floodlights. It is necessary to make separate calculations for different beam

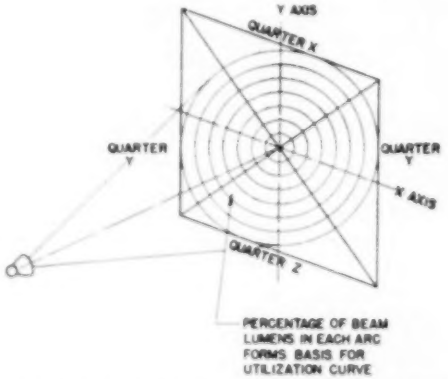


Figure 3. Computation of the percentage of the beam lumens falling in each arc provides basis for Utilization Curves.

*Values for a given set of conditions may be determined from IES Handbook, p. 6-11.

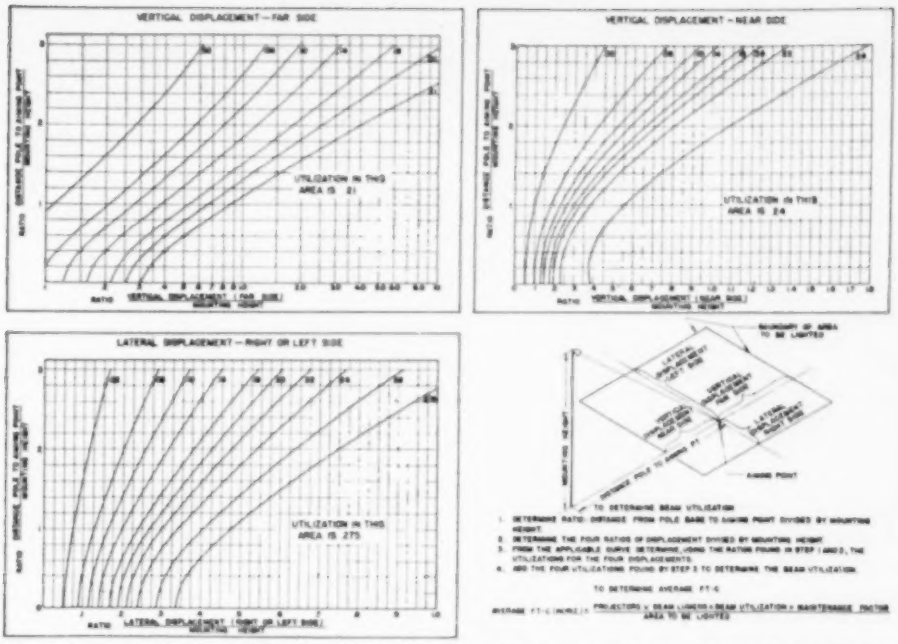

VERTICAL DISPLACEMENT – FAR SIDE
UTILIZATION IN THIS AREA IS .21
VERTICAL DISPLACEMENT – NEAR SIDE
UTILIZATION IN THIS AREA IS .24
LATERAL DISPLACEMENT – RIGHT OR LEFT SIDE
UTILIZATION IN THIS AREA IS .275
TO DETERMINE BEAM UTILIZATION
1. DETERMINE RATIO: DISTANCE FROM POLE BASE TO AIMING POINT DIVIDED BY MOUNTING HEIGHT
2. DETERMINE THE FOUR RATIOS OF DISPLACEMENT DIVIDED BY MOUNTING HEIGHT
3. FROM THE APPLICABLE CURVE DETERMINE, USING THE RATIOS FOUND IN STEP 1 AND 2, THE UTILIZATIONS FOR THE FOUR DISPLACEMENTS
4. ADD THE FOUR UTILIZATIONS FOUND BY STEP 3 TO DETERMINE THE BEAM UTILIZATION
TO DETERMINE AVERAGE FT-C

Figure 4. Completed Beam Utilization Curve for a typical floodlight. VRC-18 Narrow beam, NEMA Type 3.

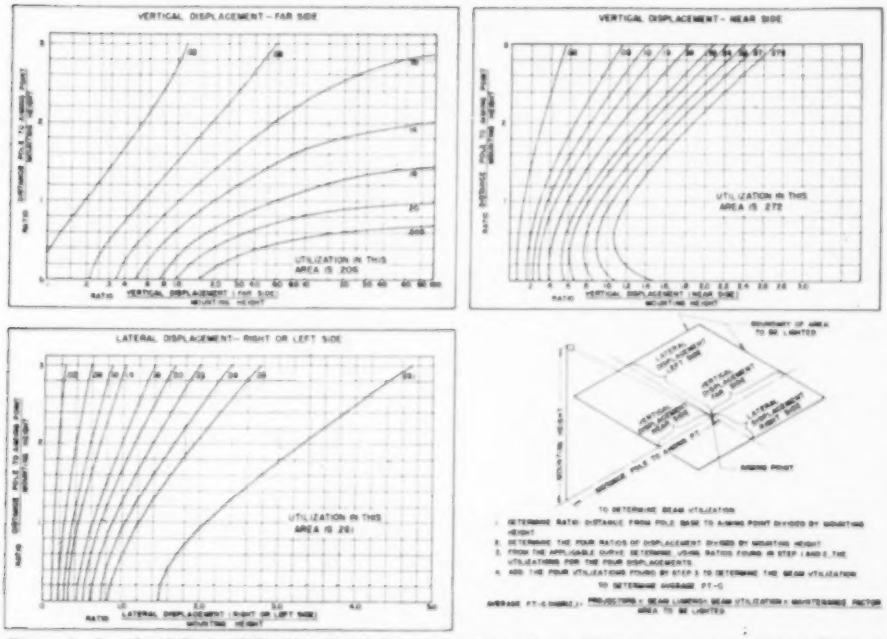

VERTICAL DISPLACEMENT – FAR SIDE
UTILIZATION IN THIS AREA IS .205
VERTICAL DISPLACEMENT – NEAR SIDE
UTILIZATION IN THIS AREA IS .272
LATERAL DISPLACEMENT – RIGHT OR LEFT SIDE
UTILIZATION IN THIS AREA IS .291
TO DETERMINE BEAM UTILIZATION
1. DETERMINE RATIO: DISTANCE FROM POLE BASE TO AIMING POINT DIVIDED BY MOUNTING HEIGHT
2. DETERMINE THE FOUR RATIOS OF DISPLACEMENT DIVIDED BY MOUNTING HEIGHT
3. FROM THE APPLICABLE CURVE DETERMINE, USING RATIOS FOUND IN STEP 1 AND 2, THE UTILIZATIONS FOR THE FOUR DISPLACEMENTS
4. ADD THE FOUR UTILIZATIONS FOUND BY STEP 3 TO DETERMINE THE BEAM UTILIZATION
TO DETERMINE AVERAGE FT-C

Figure 5. Completed Beam Utilization Curve for a typical floodlight. VRC-18 wide beam, NEMA Type 5.

TABLE I—Average Initial Footcandle Level

Type of Field	Lumen Formula Without Beam Utilization Factor	Lumen Formula With Beam Utilization From Curves	NEMA Method	Measured*
80 Unit Football Field	33	23.5	25.2	21
144 Unit Football Field	54.2	47.0	45.7	44
Tennis Court	12.7	10.8	10.6	11
120 Unit Baseball Field				
Infield	40.5	35.9	36.6	36.7
Outfield	21.0	19.4	19.0	17.9
58 Unit Softball Field				
Infield	52.5	38.3	36.6	36.5
Outfield	14.7	12.7	12.7	13.4

*Level of illumination measured by a photoelectric multicell meter with diffusing cover. Selection of measurement stations was based on the NEMA Standard Method for Floodlighting Surveys.

spread floodlights since beam lumens and the utilization of such floodlights are not the same. In baseball calculations it is usual practice to calculate intensities for both the infield and outfield; thus for baseball calculations a particular floodlight will have both an infield utilization and an outfield utilization.

Accuracy of Method

It is always desirable to know the limitations of any calculation method. In many instances, we attempt to predict footcandle levels with an accuracy greater than is inherent in the method. After the installation is complete, we wonder why the measured footcandle level does not check exactly with the calculated level. Differences in production luminaires and lamps, human error in aiming the floodlights at a specific point, variations in voltage between units and errors in measuring the footcandle level may cancel or combine to produce relatively large differences between calculated levels and levels measured in the field. Such errors, if cumulative, may be as large as 20 per cent even if care is used. If an improper method of testing, calculation or measurement is used the errors may be much larger.

Table I indicates the relative accuracy of several methods of calculation as compared to the measured footcandle level. The listing includes medium size installations for a variety of sports.

From these results it can be seen that the accuracy of the NEMA Method and the lumen formula with beam utilization factor is well within the limits to be expected—in fact for installations using a relatively large number of floodlights the accuracy of calculations using the utilization curves can be considered excellent.

A comparison of the coefficient of beam utilization for individual units obtained by the NEMA Method and Utilization Curves can be made. Such a listing for the units on the end pole of a football field are indicated as follows:

Unit	Beam Utilization From Curves	Beam Utilization By NEMA Method
1	.57	.62
2	.60	.63
3	.65	.63
4	.62	.59
5	.54	.53
6	.39	.41
7	.59	.64
8	.90	.93
9	.95	.97
10	.96	.94
Average Utilization	.705	.717

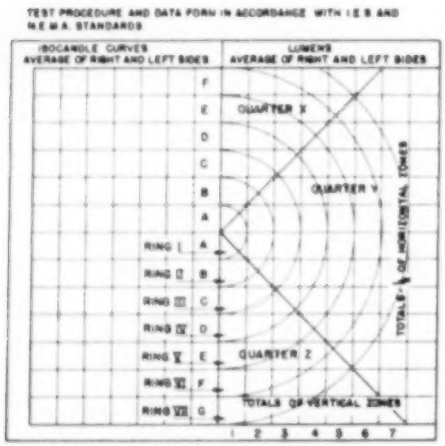


Figure 6. Method of dividing a photometric test report into concentric rings and quarters.

Summary

It has been shown that the factor "Beam Utilization" must be added to the conventional lumen method formula for floodlighting calculations before a reasonable degree of accuracy can be obtained. A method of determining the beam utilization from curves has been worked out to enable the lighting engineer to determine this factor without involved calculations. A brief analysis of the accuracy which may be expected indicates that careful use of properly prepared curves will result in satisfactory calculation of footcandle levels by the

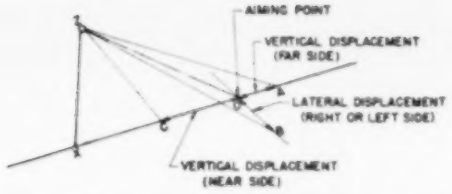

AIMING POINT
VERTICAL DISPLACEMENT (FAR SIDE)
LATERAL DISPLACEMENT (RIGHT OR LEFT SIDE)
VERTICAL DISPLACEMENT (NEAR SIDE)

Figure 7. Relationship of angles to vertical and lateral displacement from the aiming point.

lumen method. The determination of proper Coefficients of Utilization for various sized rooms enabled the illuminating engineer to use the lumen method for accurate interior lighting footcandle calculations; and in a similar manner Coefficients of Beam Utilization will permit the use of the lumen method for accurate sports lighting footcandle calculations.

Appendix I

Method of Deriving a Utilization Curve for a Particular Floodlight

Utilization curves may be calculated from a Photometric Test Report prepared in accordance with the I.E.S. Recommended Testing Procedure. The following procedure may be used to prepare utilization curves from a Photometric Test Report.

Step 1—Divide the grid system into quarters and inscribe the annular rings as shown in Fig. 6.

Step 2—Determine the total lumens in each circle (total of all rings within its boundary) for each quarter using the area factor listed below. This factor is applied only when the square under consideration is located in the outer ring of the circle under consideration. A factor of unity or 0.5 will apply in all other cases and may be determined by inspection. These factors indicate the fractional area of the square falling within the ring as shown in Fig. 6 and do not consider the distribution of lumens within each square. This approximation tends to produce conservative results in almost all instances.

Step 3—Using the totals of each circle for each quarter, as determined in Step 2, divided by the beam lumens, draw utilization curves for Quarters *X*, *Y* and *Z* using degrees to the boundary of the circle as the ordinate and percentage of utilization as the abcissa.

Step 4—Select individual utilizations in each quarter (from the curves of Step 3) which are even values and which provide suitable steps for easy interpolation, and draw the family of curves for each quarter which comprise the completed utilization curve. These curves may be drawn by using the following relationships as indicated in Fig. 7.

$$\frac{\text{Near Side Vertical Displacement}}{\text{Mounting Height}} = \frac{OC}{XZ} = \tan OZX - \tan CZX$$

$$\frac{\text{Far Side Vertical Displacement}}{\text{Mounting Height}} = \frac{OA}{XZ} = \tan AZX - \tan OZX$$

Factor to Determine Lumens Falling Within Given Ring and Quarter

Applicable to Ring	For Square in Quarter *X* or *Z*	For Square in Quarter *Y*	Area Factor
I	A-1	A-1	.39
II	B-1	A-2	.87
	B-2	B-2	.15
III	C-1	A-3	.95
	C-2	B-3	.56
	C-3	C-3	.02
IV	D-1	A-4	.98
	D-2	B-4	.68
	D-3	C-4	.15
	C-3	C-3	.47
V	E-1	A-5	.98
	E-2	B-5	.76
	E-3	K-5	.29
	D-4	D-4	.28
VI	F-1	A-6	.98
	F-2	B-6	.80
	F-3	C-6	.44
	F-4	D-6	.04
	E-4	D-5	.81
	E-5	E-5	.06
VII	G-1	A-7	.99
	G-2	B-7	.81
	G-3	C-7	.55
	G-4	D-7	.10
	F-4	D-6	.94
	F-5	E-6	.34
	E-5	E-5	.49

For example the lumens falling in Circle III (which includes Rings I, II and III), Quarter *X* would be computed as follows:

Lumens in square A-1 × 0.5 =
Lumens in square B-1 × 1.0 =
Lumens in square B-2 × 0.5 =
Lumens in square C-1 × .95 =
Lumens in square C-2 × .56 =
Lumens in square C-3 × .02 =
For Ring III, Quarter × TOTAL = × 2 = lumens

$$\frac{\text{Lateral Displacement}}{\text{Mounting Height}} = \frac{BO}{XZ} = \frac{\tan BZO}{\cos OZX}$$

where angle *OZX* is determined by $\frac{OX}{ZX} = \frac{\text{Distance to Aiming Point}}{\text{Mounting Height}}$

$$\left\{\frac{OX}{ZX} = \tan OZX\right\}$$

where angle CZX = angle OZX — angle OZC, where angle OZC is the angle determined by the selection of a particular utilization in Step 4.

where angle AZX = angle OZX + AZO, where angle AZO is the angle determined by the selection of a particular utilization in Step 4.

where angle BZO is the angle determined by the selection of a particular utilization in Step 4.

The individual utilization curves can be drawn from nine points. Convenient points to select are as follows:

$\frac{OX}{ZX} = \tan OZX = 0, .25, .50, .75, 1.0, 1.5, 2.0, 2.5,$ and 3.0.

Bibliography

1. *IES Lighting Handbook*, 1st ed. Illuminating Engineering Society, New York City, 1947, p. 8-25.

2. *NEMA Approved Standards*, National Electrical Manufacturers Association, New York City, 1935, Standard FL6-30.

DISCUSSION

J. S. HANEY*: The author has outlined a new method of calculating beam utilizations of floodlights and has compared his new system with two basic calculation methods which are referred to as "IES Lighting Handbook" method (lumen formula without beam utilization factor) and "NEMA" method (plotting area on photometric test report).

The basic formula recommended is obviously an improvement over the IES Handbook formula with the addition of the beam utilization factor and voltage factor. It would be difficult to find a practical floodlighting application where 100 per cent of the beam lumens could be used. From the information given in Table I and the comparison given by the author of the utilizations of ten floodlights on a pole of a football field installation, it appears that the new calculation method can be considered entirely satisfactory as to accuracy for most standard applications such as these, involving a substantial quantity of units. For any individual floodlight on such applications, an error of as much as eight per cent is indicated (Unit No. 1 in text). A greater error may be found where the area is irregular or the floodlight is turned at a considerable angle, which cannot be compensated for when only four points are taken on the area. It should be more strongly emphasized that the accuracy of this system may be low if applied to irregular areas, or (under some conditions) long narrow areas, such as encountered in sign lighting, smokestack lighting and building lighting.

The new calculation method outlined required a certain amount of dimensional measurements, individual calculations and four readings on utilization curves with interpolations to determine each floodlight beam utilization. Although an easier system to use than the NEMA method (after the work of calculating and plotting the utilization curves), it appears that this new system may still be somewhat complicated for infrequent use. Three utilization curves are required for each floodlight type, including a set of three curves for each reflector, lens and lamp combination of each floodlight. This means that a lighting engineer must be provided with a considerable file of curves, even for the floodlights of just one manufacturer.

It should be mentioned that a beam utilization factor can in many cases be estimated with reasonable accuracy by plotting the beam on the area to be lighted as shown in Figure 1 in the text, and estimating the percentage of the beam falling on the area. The accuracy of such estimates can be raised by:

1. Calculating utilization of two or three floodlights for a specific application by the "NEMA" method, which will give a check on the estimated utilization, and which will be a guide for the remaining floodlights.

2. Checking on actual installations and comparing actual readings with previously estimated footcandle levels.

In connection with estimated utilizations, it should be emphasized that the lumens are always more concentrated in the innermost portion of any specific part of the floodlight beam. For example, if any of the squares such as B-3 in Figure 6 is divided in half, there will be more lumens in the half toward the center of the beam than in the outermost half. Although the actual area of the beam falling on the football field might be only 60 per cent in respect to the total area covered by the beam, the beam utilization might be 65 per cent or 70 per cent.

The accuracy of the calculation method proposed by the author could be raised by taking percentage of actual lumens in each portion of each square rather than percentage of area. As stated in Appendix I, step 2, using area distribution rather than lumen distribution tends to produce conservative results. It would seem desirable, however, to go just a little further and make the utilization curves as accurate as possible by taking actual percentage of lumens as described in the above step for determining the curves.

We would recommend that the beam utilization curves be plotted directly in percentage of lamp lumens rather than percentage of beam lumens. This will eliminate one operation in each floodlight calculation, namely, that of multiplying the beam efficiency by the beam utilization before inserting it in the basic formula.

It might be well to mention what the maintenance factor should be for typical cases. For a floodlighting installation which is well maintained, the maintenance factor is usually close to 75 per cent for enclosed floodlights and 65 per cent for open floodlights. These figures are based on cleaning the fixtures thoroughly at least once per season in relatively clean locations, and twice per season in dirty or smoky locations. These figures are also based on replacing lamps which show considerable blackening and are, therefore, close to the end of useful life. The above factors are now generally considered to be more accurate for practical use than the overall figure of 70 per cent mentioned in the IES Handbook (page 8-25).

F. D. WYATT**: The author has reviewed the *total useful lumen method* and the NEMA or point-by-point method of applying floodlights for area or sports lighting. The figures in Table I indicate that the total useful lumen method is optimistic and that corrections which the author suggests give quite accurate results. The labor of calculations either the point-by-point or the author's suggested *beam utilization* curves is about equal at 10 hours for either method for the example given.

The advantage of the author's method is that the *beam utilization* curves once drawn for a given floodlight at specified mounting height and aiming distance can be used on other installations.

I would take exception to the author's implied as-

*Crouse-Hinds Company, Inc., Syracuse, N. Y.

**Chicago Park District, Chicago, Ill.

sumption that light on a horizontal surface is the principal consideration. In many sports arenas the light component on a vertical surface is often more important for spectator vision and enjoyment. For example, at Soldiers Field in Chicago, the spectators' line of sight is 5 to 12 degrees below the horizontal whereas the light is directed at the field at 18 to 24 degrees below the horizontal. Admittedly close control of light output from the floodlight is required to avoid disturbing glare from the floodlights across the field. Most satisfactory results have been secured on this job. A simple method of calculating light on vertical planes in the lighted area would be of value in sports and area lighting.

The introduction of *beam utilization factor and voltage factor* should be of considerable value in calculating floodlight installations in the future and shows constructive progress.

J. E. Bock*: Mr. Keck's paper adds another method of computation, predicting illumination values of sports and kindred areas and it is another step toward finding a solution to these laborious processes of being able to compute footcandle values easier and more accurately. The effectiveness of the method can only be measured by its usage and the difficulty or ease by which, first, the beam utilization efficiency can be determined, and secondly, the time involved, accuracy, etc., in making these calculations for the many various conditions with which one is confronted.

It would have been very helpful to future users if a step-by-step account had been given, as for example, on a 120-unit baseball field installation, particularly indicating the effect on the beam utilization or the subsequent calculation when the aiming point is at the corner of the area and at a very oblique angle to the near side or far side displacement.

I also have a question as to the significance of using ring areas in determining the beam utilization rather than the rectangular or square degree spacing on the photometric data. The effectiveness and accuracy of the NEMA method has proven itself beyond the shadow of a doubt during all the years it has been in use. If one chooses certain fundamental groupings and conditions and the area diagrams thus once established, the utilization efficiencies of various floodlights can be computed, plotted, and tabulated in a manner which will also reduce the final calculations of, for example, baseball and football field installations to almost a matter of minutes.

M. E. Keck**: Mr. Haney's comments are appreciated very much and serve to bring out several points which the author could not completely cover in the original paper due to time and space limitations.

It is quite true that this calculation method will show a considerably greater error when applied to an area which is much larger in one dimension than in the other, however, the calculation method was not intended primarily for such applications as smoke-stack lighting and sign lighting. In any event the use of the utilization curves to provide a beam utilization factor will always result in more accurate calculations than if no consideration is taken of the spill light.

As indicated by Mr. Haney a beam utilization factor can be estimated by plotting the beam on the area to be lighted, however it is my opinion that considerable experience is necessary before the utilization can be estimated with reasonable accuracy since, as he so correctly points out, it must be remembered that the lumens in the beam are not distributed evenly over that beam and an area estimate alone is far from accurate.

It is true that the accuracy of the utilization curves could be improved slightly by using a different method of arriving at the fraction of the lumens in each square in each quarter arc, however, this was carefully considered by the author who feels that the gain in accuracy would not be sufficient to justify the difficulty of arriving at an exactly true percentage of the lumens.

The question as to whether the coefficient of utilization for floodlighting calculations should be based on beam lumens or lamp lumens is one which should be settled by the proper committee of the I.E.S. The author has used beam lumens for two reasons: first, all previous calculation procedure for floodlighting has used beam lumens, and, secondly, the use of lamp lumens would require a change in the Recommended Testing Procedure for Floodlights since at the present time the entire beam is not explored and the overall efficiency of the floodlights is not determined.

I certainly agree with Mr. Wyatt that it would be of value if a simple method of calculating light on vertical planes from many sources could be worked out. I did not intend to imply that light on a horizontal plane should be the only consideration in sports lighting, but it is easier to calculate, and the proposed utilization curves can only be applied in calculating the average horizontal footcandles.

The answer to Mr. Bock's question in regard to why ring areas were used rather than rectangular or square areas is one of accuracy. Both ring areas and square areas were tried and it was found that, when the floodlights were aimed at angles such that the straight lines of the area to be lighted were not parallel to the edges of the square areas, then the accuracy was much lower than if ring areas were used. I am interested in Mr. Bock's statement that the final calculation of footcandle levels for football and baseball fields can be made in a matter of minutes from a properly prepared tabulation of certain data compiled from fundamental groupings, conditions and area diagrams. In one sense that is exactly what has been done in the preparation of these utilization curves. However, if an easier or more effective way is known by Mr. Bock then I feel that he should publish such a method together with an analysis of its accuracy.

*General Electric Company, Lynn, Mass.
**Author.

Modern in Southern

Jewelry Store

Strasburg's of Hollywood Inc.
6628 Hollywood Blvd.

The Lighting system for this sales area in Hollywood, California has been designed to be in keeping with the dignified elegance of the merchandise sold exclusive jewelry. Recessed PAR38 150-watt flood and spot lights mounted in canopies over the counters provide 150 footcandles on the counter tops.

All lighting data and photographs shown on these pages have been submitted by the Data Sheet Committee of the Southern California Section, through T. H. Shepherd, Regional Vice-President.

Street Lighting

The excellent building-to-building illumination of South Broadway in Los Angeles, represents one of the finest street lighting installations in Southern California. FH-1 400-watt mercury lamps are used with two-unit GE81-D luminaires having No. 232 light alabaster rippled globes. Mounting height is 28 feet to lamp center, with the units spaced at approximately 120 feet. A maximum of 3.5 ft-c, and 2.5 ft-c average is maintained.

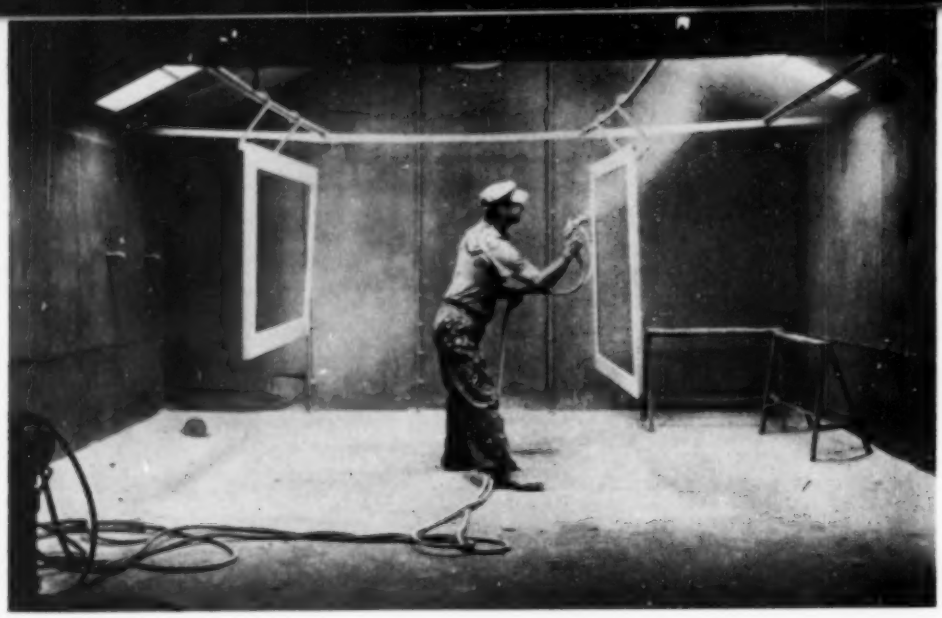
Lighting California

Sportswear Dept.
Mullen and Bluett Store
5570 Wilshire Blvd.

A unique lighting effect is achieved at the Mullen and Bluett store, Los Angeles, with a custom-made oval troffer using 10,000 watts of combined fluorescent and incandescent lighting. The 400 square-foot oval, manufactured by Solar Lighting Co., is mounted at the 15-foot ceiling of the 43-foot by 36-foot area. Decoration and lighting were designed by Burke & Kober, Los Angeles. Lighting data from the Southern California Section Data Sheet Committee, Harry Morton, Chairman.

Ladies Sales Department

The sales area for ladies shoes in the Mullen and Bluett Store, Los Angeles, features recessed incandescent and cove lighting for high-level lighting of unobtrusive dignity. The 8 ft x 15 ft drop cove in the center of the room uses seven 300-watt lamps on 5½-foot centers in line on each side of the cove. Illumination level is 50 footcandles. Installation planned by Burke & Kober, equipment by Solar Lighting Co.



Fluorescent Lighting for a Spray Booth

A UNIQUE method of lighting a spray booth with fluorescent fixtures was accomplished at the Chamberlain Metal Products Company, Detroit, still keeping within safety requirements of local inspection departments, and at the same time within reasonable cost. The previous installation was of incandescent, explosion-proof type, condemned by insurance underwriters because of too high surface temperatures for use with pyroxylin enamels.

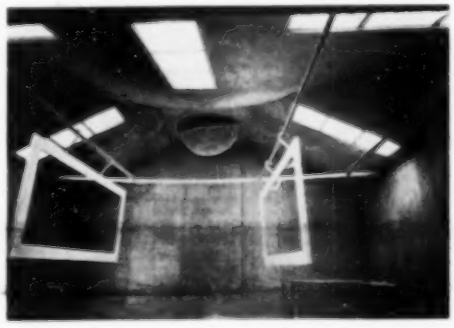
Five vapor-tight fluorescent fixtures with three 40-watt lamps were used, mounted flush in the ceiling. The joining of the fixture and the ceiling is gasketed with a soft metal. The installation provides 85 footcandles of uniform, well-diffused light.

Maintenance is accomplished through a door in the side of each fixture from outside of the booth. (An accessory hanger is available which will allow maintenance from inside the booth.) The glass lens of the fixtures are painted with a thin coat of liquid wax to allow for easy cleaning without the use of explosive solvents.

Where this type of installation is used in extremely hazardous locations, further safety can be achieved by the introduction of an air line connected to a pressure switch and a pressure of one pound maintained at the fixture internally. In the event of accidental breakage or leaks, the air pressure drops, shutting off the power from a point outside the booth, thus eliminating any chance of fire caused by the damaged fixture.

As the cost of this type of equipment is a fraction of the cost of explosion-proof fluorescent fixtures, and has a very low surface temperature on the special heat-resistant lens it is felt that this type of lighting for hazardous areas may well become standard practice. Local approval of such practice should be requested for each individual job.

Details of this installation were supplied by Duncan Preston, Lighting Division of the Detroit Edison Co., Detroit, Mich.



Color Preference Studies with Fluorescent Lamps

By G. B. BUCK II

New spectral reflectance data are presented for representative items, including foods, complexions, and various environmental materials. They are shown in relation to preferred color of light source as selected by approximately 2,500 lay observers. These results are supplemented with laboratory studies for which the spectral character of the incident light was closely controlled throughout a wide range, permitting a closer determination. Applications to lighting practice and lamp design are indicated.

THE INTENT in nearly all lighting practice is to direct one's attention to objects and the environment rather than to light sources.[1] Hence, in general, we are more concerned with the color appearance of materials than sources. Experience gained with the first fluorescent lamps over ten years ago showed that the simple matching of lamp color to filament or to "average daylight" does not establish the optimum spectral distribution for the color appearance of materials.

Color rendition of materials is controlled by the relative amount of the various wavelengths of light from the source, not by its own color appearance. This becomes apparent when the differences in appearance of identical materials are noted under such color-matched sources as filament and warm tint, or 4500° white and photocolor fluorescent. A more rational approach to lamp design and application becomes possible by a systematic study of the rendition of materials and the individual source preferences of a large number of people.

Human activities take place in many types of interiors, but in two basic, "working" and "social" environments. The former includes offices schools, factory areas, some stores and some places in the home, *e.g.* kitchens and laundries. The latter encompasses restaurants, theatres, lounges, lobbies, bars, some stores, and such parts of the home as the living and dining areas. Since light is the stimulus for our most important sense, it is understandably a major environmental factor. Conversely, the character of the environment is of great significance in light source reference. One must consider both materials of design which are generally controllable in color and others, *e.g.* complexions and foodstuffs, which are usually not subject to control.

Field Test Facilities and Techniques

Some of these studies invovled the comparison of about 30 sets of identical samples, shown under five to seven standard and developmental sources. Table I summarizes such observations by approximately 2,500 different people at I.E.S. meetings, university classes and the Lighting Institute at Nela Park.

The color impression of an object is affected not only by the spectral character of the source, but also by the surroundings and by the physiological and psychological characteristics of the observer as conditioned by his past history. Consequently, while one can establish the degree of preference of a large group, individuals will differ. Among the factors which may influence such preference studies are: the number and order of sources in the booths, the illumination level, the size and surroundings of the sample, and the color adaptation of the ob-

TABLE I.—Summary of Lamp Preferences Found for Various Materials*

Materials	3000K Fils.	Soft White	Warm Tint	3500K White	4500K White	6500K Daylight
Red Cardboard	2	1	5	4	3	6
Yellow Cardboard	2	3	1	2	4	5
Green Cardboard	1	6	2	3	4	5
Blue Cardboard	5	5	6	4	2	1
White Cardboard	5	4	4	2	1	3
Brown Cardboard	1	4	3	2	1	5
Multicolored Cloth	4	1	5	3	2	1
Blonde Complexion	2	1	4	3	5	6
Hair	1	1	2	2	3	4
Brunette Complexion	2	1	5	3	4	6
Hair	2	1	6	4	3	5
Titian Complexion	1	1	4	2	3	5
Hair	1	2	4	3	3	5
Milk	1	3	4	2	3	3
Coffee with Cream	1	2	5	3	4	5
White Bread	2	1	5	3	3	4
Brown Bread	1	1	4	2	3	5
Butter	1	2	3	3	4	5
Cooked Meat	2	1	4	3	4	5
Lettuce	1	1	2	1	2	2
Green Pepper	1	1	2	1	2	2
Tomato	1	2	5	2	4	6
Food Display**	2	1	5	2	4	6

*Simultaneous viewing of matched samples in adjacent booths, except for models who walked from booth to booth.

**Viewing as an ensemble all foods listed above.

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Author: General Electric Co., Nela Park, Cleveland, Ohio.

TABLE II—Preference and Dislikes for Average Brunette Model Under Various Sources (710 Observers)

	New Soft White	Old Soft White	Filament	4500 White	3500 White	6500 Daylight	Warm Flat 3000
Preference Votes	161	154	133	86	109	41	72
Dislike Votes	14	21	26	21	24	111	54
% Preferences	22	22	18	12	15	6	9
% Dislikes							
Order Preference	1	1	2	2	2	4	3
Order Dislikes	4	3	3	3	3	1	2

servers. Other psychological factors include temperature, humidity, season, time of day, general state of health, etc. To minimize such factors, the arrangement of the sources, the order of presentation of materials, etc. were varied.

Many studies were run where the observers noted "dislikes" as well as "preferences," *e.g.* Table II for 710 observers viewing the same brunette model. Apparently the negative criterion is easier for some people.

Laboratory Studies

Viewing samples side by side under the various sources, does not allow one to become adapted to any given sources as in an actual installation. A still more critical evaluation is possible by comparing only two sources at a time in adjoining booths, or by alternate viewing with lamps on instant start ballasts in one booth. The former was useful for prolonged comparisons, the latter for unique samples, *e.g.* complexions. The use of three booths was found to be unreliable due to the strong tendency of observers to select the "middle" condition. Even with four booths, results varied somewhat if one source differed conspicuously from the others. The apparent psychological reaction was to reject the "different" lamp rather than evaluate its rendition characteristics. When five to seven booths were used the results checked closely with the two-booth elimination method.

To supplement the booth studies, laboratory facilities (Fig. 1) were constructed to determine preferences with the greater range of illuminants possible by mixtures of present lamps or by new phosphor combinations. Both mechanical and electrical dimming methods were used, so arranged that observers had only to adjust one or two dials to vary the spectral composition of the resultant light. Some of the lamps were on compensating circuits so that illumination remained substantially constant. Each lamp was measured by an individual light-sensitive cell to permit reading the resultant color from an I.C.I. color mixing nomogram.[1]

Complexions

The study of environmental factors was begun with complexions because these are seen under all lighting conditions and frequently become the major criterion.[2] Several hundred spectral reflectance measurements were made on selected individuals and are summarized in Fig. 2. Preference studies were carried out with 1,051 observers viewing statistically average complexions. The similarity of the spectral emission curve of the preferred source to the reflectance curve for the complexion is obvious. Fig. 3 indicates the relationship of the order of lamp preference to its spectral nature as recently found with 809 observers.

When a blonde model was viewed, 679 observers

Figure 1. Laboratory setup for color preference studies.

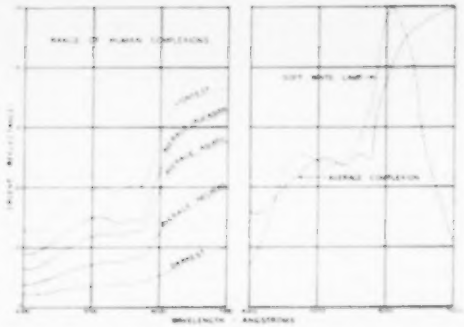


Figure 2. Spectral reflectance characteristics of human complexions and comparison of spectral emission of soft white lamp with average complexion. Mercury lines omitted for clarity.

gave the same preference order except that warm tint and 4500° white exchanged fourth and fifth places and the margin of soft white over filament was less pronounced. When a titian model was viewed, 705 observers gave equal preference to filament and soft white. These changes are apparently due to the enhanced appearance of the blonde hair under warm tint and the red under filament. The spectral similarity of human hair and these two sources may be seen by comparing Fig. 4 with the sources in Fig. 3. Laboratory studies revealed the limited areas of the I.C.I. diagram preferred by observers viewing complexions when several types of phosphors were used—Fig. 5. Final preference was then obtained by a comparison of the area centers for the different combinations. It is significant that these preferred areas are all located beneath the traditional color temperature locus. It is of interest that a small difference was noted between summer and winter studies although not sufficient to affect the preference order.

Foods

For 786 observers viewing coffee with cream in the booths, the preference order in Table I was found. Fig. 6 shows the spectral similarity of coffee

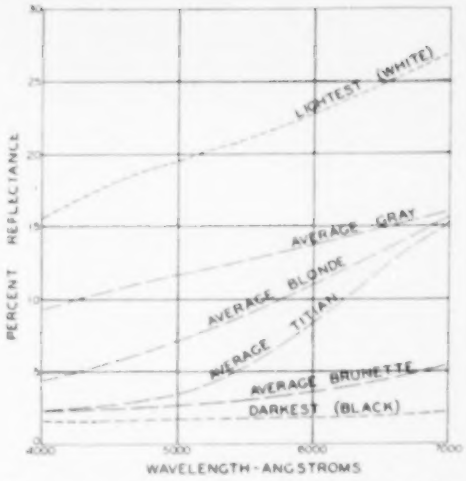


Figure 4. Spectral reflectance characteristics of human hair.

and the "most preferred" filament lamp and the almost complementary nature of the "least preferred daylight lamp. Preferred areas on the I.C.I. diagram for a group of foods viewed as an ensemble are given in Fig. 7. Preference orders are listed in Table I for the individual foods and the ensemble, Fig. 8.

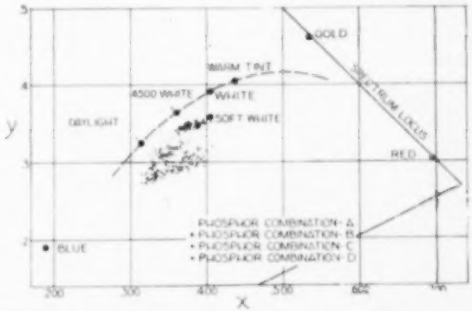


Figure 5. I.C.I. chromaticity diagram showing preferred areas for complexions.

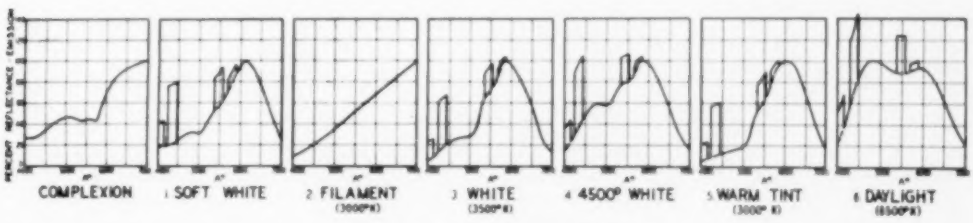


Figure 3. Lamp preference order

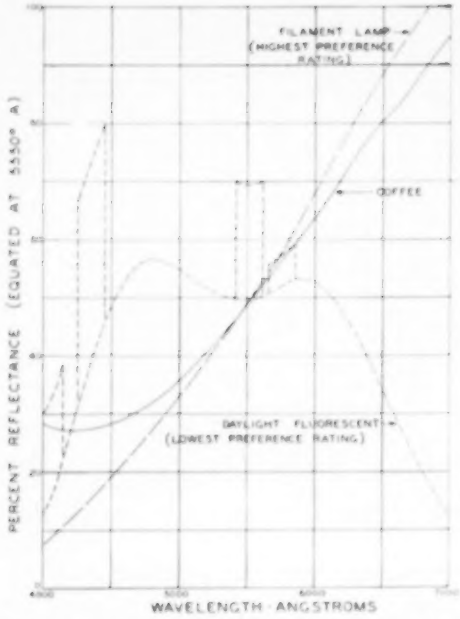


Figure 6. Spectral reflectance of coffee (with cream) compared with emission data for two lamps.

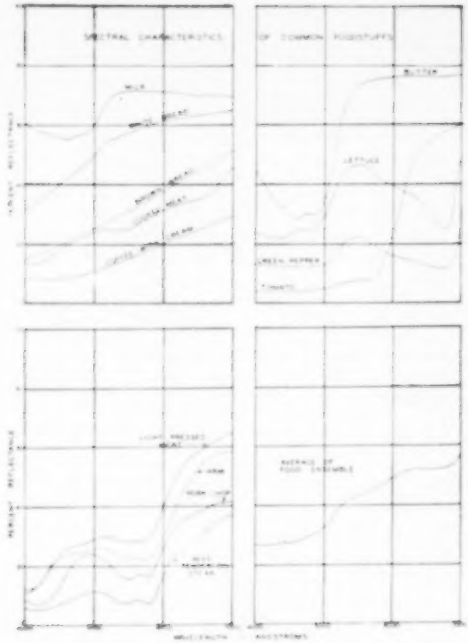


Figure 8. Spectral characteristics of common foodstuffs.

Materials of Design

With the more objective materials, *e.g.* colored cardboards, fabrics, wallpapers, etc. the degree of preference is often pronounced. In the classical example of the blue material, Table 1, Fig. 9, 80 per cent of the votes cast by 1,068 observers were for the daylight fluorescent lamp. The preference was 38 per cent for warm tint on the yellow material; 48 per cent for soft white on red and 51 per cent for 4500° white on white. Apparently the choice, for one color viewed at a time, is for the

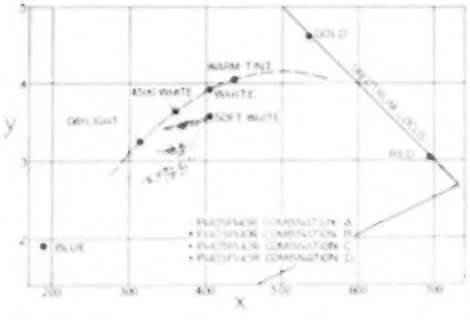


Figure 7. I.C.I. chromaticity diagram showing preferred areas for a prepared food ensemble.

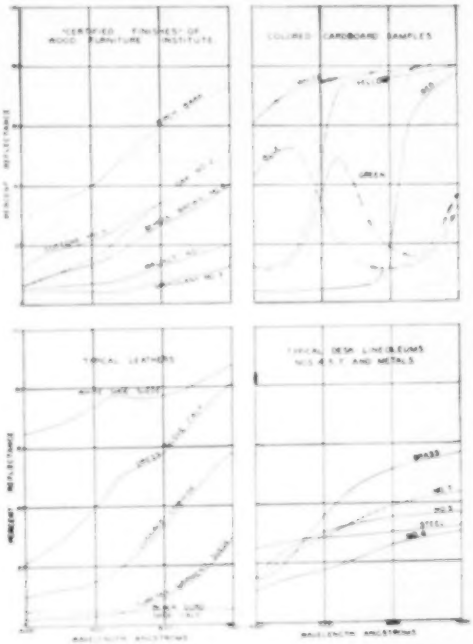


Figure 9. Spectral reflectance data for various materials.

lamp that enhances saturation and brightness with minimal shift in the hue of the sample. Limited studies with blue lamps indicate preference over daylight. Since little information has been available on the spectral reflectance of common materials, such data were taken and typical curves are presented in Fig. 9.

In most environments, the harmony of the entire color scheme is paramount, and this leads to a different evaluation which can be made by observing the several colors of the ensemble as a unit. This was done with multi-colored wallpapers and textiles and can often be advantageously applied with wider scope.

Color Inspection and Discrimination

The requirements for color inspection in industrial lighting practice may be just the opposite. Here one may emphasize flaws by increasing contrast. Small variations in color are most apparent when the source is spectrally contra to the reflectance of the material.[3] This has led to the development of a color inspection fixture employing filament, daylight, and blue fluorescent lamps, which is now available through at least one manufacturer. By the use of several circuits, one can vary the spectral quality of the light for critical inspection

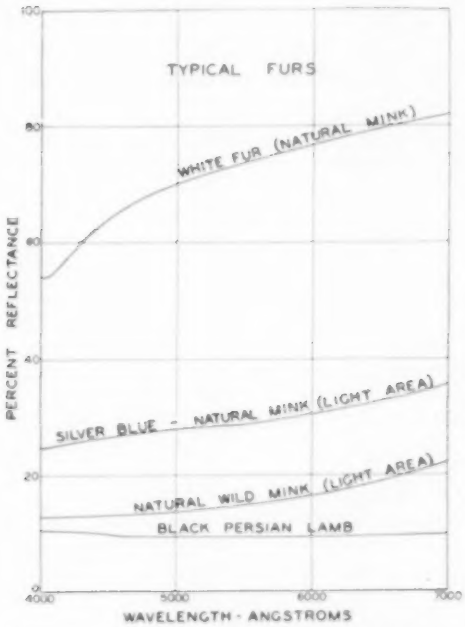


Figure 10. Spectral reflectance data for typical furs.

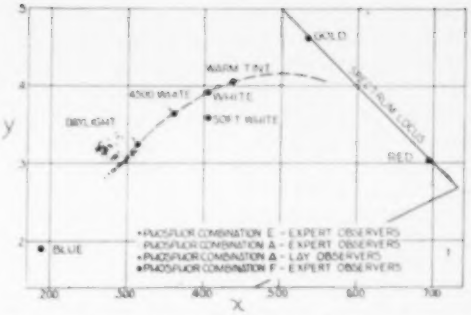


Figure 11. I.C.I. chromaticity diagram showing preferred areas for typical furs.

of various colored materials; and the efficiency of fluorescent lamps permits high illumination values. With all circuits on, a spectral distribution and color approaching equal energy is obtained.

Furs—One interesting exception to the "preference rule" is the case of fur displays. Extensive studies were carried out with both professional and lay observers viewing a wide range of fur coats valued from about $200 to $10,000. The preferred sources were selected by alternately viewing with illumination from instant start lamps of different colors in a single booth. Overwhelming preference was found for the daylight lamp on all fur types even though it is not spectrally similar but nearly complementary to the furs themselves, Fig. 10. When various lamp combinations were tried in the laboratory the final preference was found to be very near the 10,000K point, readily attainable from daylight and blue fluorescent lamps in the ratio of 3 to 1, or with several other combinations of standard lamps.[1]

It may be that, since the fur experts are buyers as well as sellers, they have developed preference for that source which enables best evaluation of the garment quality. Another factor is the association with cold environments. Further, the color contrast may be enhanced when the furs are seen against a neutral gray or blue-gray background which many furriers employ. The laboratory data by the experts show much closer grouping, hence indicates a more definite criterion than used by the lay observers, Fig. 11.

Fluorescent Lamp Applications

While general observations indicate emphasis in working areas on a cool, neutral environment, the balanced appearance of a wide variety of colored materials also may be important. Such requirements are well met by a source approaching equal energy spectrally; *e.g.*, 4500° white. This, together

with lack of sharp contrast with natural light accounts for the rapid and sustained growth in the use of this lamp, now dominant in commercial and industrial lighting.

Social environments, including some types of shops, require a warm source with more yellow and red for favorable rendition of complexions, foods, and the more usual woods, floor and wall coverings. The spectral nature of filament light appears to be particularly well suited for these. Although the new soft white was specifically designed for such situations, under some conditions, its color requires greater care in selecting the color ensemble. The warm tint not only shows the red deficiency characteristic of many fluorescent lamps, including the 4500° white, but also is the most blue deficient, Fig. 12. The lack of red may be effectively supplied by the addition of filament lamps, which also give enhanced appearance to many specular or textured materials, but the blue deficiency remains. Properly chosen combinations of fluorescent and filament lamps permit the creation of an "outdoors" illusion through brightness pattern characteristics of diffuse skylight plus directional sunlight. Another available corrective is the addition of red-emitting phosphors, as in the photocolor lamp, Fig. 12, matching 4500° white in lamp appearance but giving more accurate and complete rendition of the range of colors.

The daylight lamp has particular application where a cool environment appearance is a major objective, as in southern climates. Analysis of 40 and 100-watt fluorescent lamp sales by geographical areas show preference for daylight lamps vary progressively from about 15 per cent in the northern states to over 45 per cent in the most southern.

Environmental Materials

From Figs. 2, 4, 8, 9, and 13 it would appear that environmental materials have the characteristics of increasing in reflectance with the longer wavelengths of light, *i.e.* reflect more red than blue and are "warm" in appearance. If spectral measurements of the twenty-four paints, woods, drapes, carpets, tiles, linoleums and acoustical materials used in the various rooms of the modernly appointed Lighting Institute are averaged, we find the result shown. The above data indicate the high preference ratings of soft white and filament lamps are due to their spectral compatibility with this dominant characteristic.

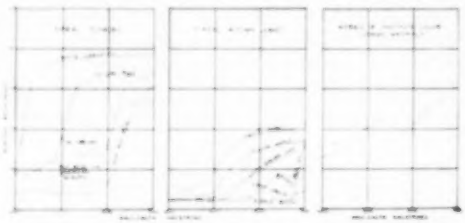


Figure 13. Spectral reflectance data for various materials.

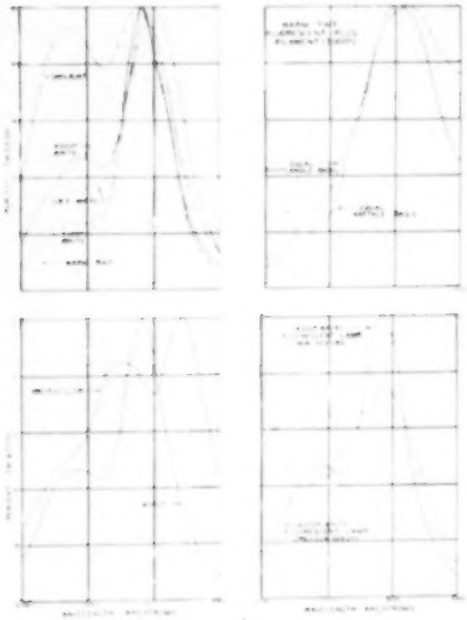


Figure 12. Spectral emission characteristics of fluorescent lamps. Mercury lines omitted for clarity.

Effect of New Phosphors on Lamp Design

The new, higher efficiency halophosphate phosphors characteristically emit less deep red radiation than former types. Interchangeability between the new and old lamps as to color rendition has been made possible by a modification of the phosphors, Fig. 12, in the direction of less blue radiation effecting a slight over-all shift in lamp color toward the red. This change amounts to about six or eight steps in minimum perceptible color difference under laboratory conditions,[4] an amount scarcely noticed by lay observers under field conditions. The degree to which these new lamps reproduce the color rendition characteristics of the previous designs on various materials is indicated by Fig. 14. The points marked "x" indicate the color appearance that

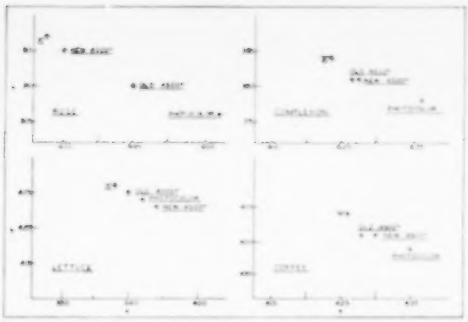


Figure 14. I.C.I. chromaticity coefficients for the colors of several materials under sources matching in appearance.

would have been obtained if lamps of the new design had merely been matched to the old in source appearance. For example, the shift in appearance of complexions would have been toward the blue-green. The spectral characteristics of these new white fluorescent lamps are as given in Fig. 12.

Acknowledgement

The author desires to express appreciation to Messrs. C. N. Clark, E. T. Lappelmeier and E. S. Steeb, Jr. for their generous assistance in obtaining the data here presented.

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DISCUSSION

LESTER C. TWICHELL*: This latest of the series of papers on the same general subject has brought out additional helpful data to add to that of previous papers. Some of the information and conclusions given in the two paragraphs on furs are rather disturbing, however. I am afraid that the application of these conclusions to retail fur establishments will bring disappointing results to the lighting advisor and to the proprietors.

Since the birth of the fluorescent lamp, many of us in the lighting industry have talked to ourselves about the daylight tube being the ideal lamp for fur stores—the outside environment, etc. We have tried it and have not found it successful.

Our most recent experience was with a local, modern fur retail establishment. There are three separate selling areas on this street floor. The first was lighted with 3500° fluorescent lamps combined with incandescent spots, the second lighted with spots only, and the third, with straight 3500° fluorescent. The straight 3500° fluorescent area was greatly criticized from the beginning. We experimented on the premises with various colors of fluorescent lamps, including daylight. The final choice was warm tint, though this was far from satisfactory until incandescent spots were added. Buck's article was apparently just concerned with spectral distribution. In the selling of furs, however, luster and sheen are tremendously important, and incandescent spots are necessary to bring out this feature. The more diffuse fluorescent sources leave the furs dead and lifeless by comparison.

Figure 10 of this paper gives as "typical furs," white fur, silver blue, natural wild mink, and black Persian lamb. Then he mentions "viewing a wide range of fur coats valued from about $200 to $10,000." Whether the four furs listed make up the "wide range" or not is not stated. If they do, it may partially explain why the results from the laboratory techniques and professional observers are at variance with our practical merchandising experience. They may have been looking for something else in the furs than the normal purchaser does—and may have been looking at a different type of fur than what the average buyer sees.

E. M. STRONG**: Ingenuity and courage keynote this study of a most complex and elusive subject.

In his study of furs the author distinguishes expert from lay preferences. Do his data on other studies provide similar distinctions? What assurance have we that lay observers provide any reliable correlation between their liking and that which is going to give them sustained satisfaction?

Consider eating; conflicts between liking and welfare are nearly universal not only in kind but in amount. Consider color; we liked the paint sample fine but living with so much of it on the walls was unbearable. Next time, if wiser, we temper abstract liking for the sample with applied experience.

I like to think that not only in school and college do we have a responsibility to orient the tastes of people to choose and like that which promotes their welfare and sustained happiness. Mr. Buck can contribute notably to this objective if he can separate mere preference from well founded preference and promote the latter among people who may be unfortunate in the former.

The author's omission of the mercury lines in Fig. 12 may be misleading. These lines are not negligible and their influence on the color appearance of an object of course can be not only considerable but too often unlikeable.

Mr. Buck repeatedly directs attention to the similarity of spectral distribution curves for the preferred light source and the object or materials. Correctly he interprets this as a preference for enhanced saturation of the dominant hue, but it should be made quite clear

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that this preferred similarity must not be taken by anyone as in the nature of a match, indicating harmony, compatibility or the like.

Note that the source curve describes the amount of light produced for each wavelength or hue but that the other curve is a reflectance curve showing, for *theoretical white light* on the material, the spectral distribution of the reflected light.

Now when as in this study the colored material is to be lighted not by the theoretical white light source but by the colored source the appearance of the material is described by the product of the two curves which, if fully "matched," is the square of either one of them. This important curve differs notably from any that the author shows, although he might easily have provided it, for example, in Fig. 6 for the coffee lighted by filament lamp.

It is not clear to me that this "matching" preference is profoundly significant although certainly it is interesting. Of course, the freshened appearance which this enhanced saturation provides is pleasingly striking but coffee color lighting probably would not enhance the lettuce salad and the application of the phenomena to general lighting is not apparent. "Louder" coffee is striking—so what? Do we change the lamps, wear coffee spectacles, or dye the coffee?

No doubt a study such as this would not have been inspired except that we have as yet failed to produce general purpose white fluorescent lamps without spectral bumps in them. The daylight lamp fails to give color satisfaction mainly because of the mercury lines which are unfavorable to complexions and many foods. The several off-white whites arise not as fundamentally desirable or necessary sources but only as crutches to limp around on until the real problem is solved.

D. B. Judd*: It is suggested in this paper that two distinct attitudes of the observer have to be considered in preference studies of fluorescent lamps, one appreciative, the other critical. For the appreciative observer, the lamp that enhances the saturation and lightness of the object-color perception of interest will be preferred; for the critical observer the lamp that enhances the color difference between the objects to be compared will be preferred. It is stated that the condition to be satisfied by the lamp for the appreciative observer is that the spectral distribution of radiant flux be similar to the spectral distribution of reflectance of the object of interest; and that the condition for the critical observer is that the spectral distribution of the lamp be supplementary ("contra") to that of the objects to be compared. This is a striking and no doubt useful principle with few exceptions of any practical importance, but it may be worth while to point out that not all yellows are best discriminated by blue light. As clearly implied, though not explicitly stated by Taylor,[3] the requirement for good color grading is that the lamp supply energy throughout the visible spectrum with a preponderance in the spectral regions where the objects to be compared exhibit the greatest percentage difference in spectral reflectance. This is usually, though not always, in the spectral regions of greatest absorption. If we have two yellow objects whose reflectance curves are identical for wavelengths less than 650 mu, but different between 650 and 750 mu, it would do no good to use an illuminant with a preponderance of energy in the region (400 to 450 mu) of maximum absorption. What is required is an illuminant with a preponderance of energy in the region (650 to 750 mu) where the two objects show the greatest percentage difference in reflectance. I agree, however, with the main conclusion of the paper which is that the generally yellowish and reddish character of our complexions and environment require for the appreciative attitude a light source on the "warm" side. Mr. Buck has made out a good case for the filament lamp and the soft white fluorescent.

Dorothy Nickerson**: Publication of spectrophotometric curves of common objects provides useful information for studying the effect of light on the color of objects. Spectral absorption bands occur in many of our most commonly viewed objects—the human complexion, meats, eggs, fruits, vegetables, and it is undoubtedly true that certain of the peculiar color effects of many common objects viewed under fluorescent light (of any commercial color so far developed) are caused by the combination of these absorption bands with spectral distributions of fluorescent lamps—spectral distributions that differ widely from curves representing either natural daylight or incandescent tungsten. The lack of red in the fluorescent is another great offender in this respect.

The appearance of scrambled eggs under fluorescent light always shocks me, even when served under a combination fluorescent-and-tungsten lamp in my own living room. Regardless of preferences as between lamps, there are many such objects that do not look natural, or cannot be recognized for normal quality, under fluorescent lamps. Processed foods such as dark cherries, grapes, cranberries, and certain jellies—anything with much red, particularly reds toward the purples—change color so much under fluorescent illumination that their quality, as indicated to the professional grader or to the discriminating homemaker, is completely masked. Fluorescent lamps are here to stay—they have so many good qualities that often they will be used in spite of their spectral distributions—as for a reading lamp in a living room. It should therefore be construed as no criticism to ask that an increasing amount of information be provided regarding the common objects that are most changed from their daylight color, or are most objectionable under fluorescent light. Such a listing would aid many a lighting man to avoid putting fluorescent in the wrong places. To my mind a study of objectionable colors would be quite as important as preference studies.

Above all, let us have more information regarding the spectro-photometric distribution of the colors of common objects, particularly in the form of original

*National Bureau of Standards, Washington, D. C.

**U. S. Dept. of Agriculture, Washington, D. C.

curves for single measurements. One member of this Society who has a great deal of this type of information on processed fruits and vegetables is Professor Leland Brown. He obtained the data in the course of a cooperative study of his local IES group with the National Canners Association regarding illumination for inspection and other purposes in processed foods plants. It would be useful if the I.E.S. could persuade Professor Brown to prepare this material for publication. Information such as Mr. Buck has included in his paper is extremely useful—we need more of it.

G. B. Buck, II**: The pertinent and complimentary remarks by the discussors are very much appreciated; they afford opportunity to clarify several points covered all too briefly in the abbreviated paper.

Dr. Judd's comments lend emphasis to the basic approach and conclusions of the paper and further clarify the spectral requirements of sources for optimum color discrimination. In dealing with color rendition of specific objects, the lighting specialist usually wishes either to "enhance the saturation and lightness" (of specific complexions, merchandise and foodstuffs, etc.) or to "emphasize small color differences or defects" (as in color "grading" or color "matching" in industry). Dr. Judd's characterization of these two attitudes as "appreciative" and "critical" is neat and concise. Perhaps for general usage it may even be more clear to differentiate lighting for "color appreciation" and for "color discrimination." But there is a third consideration to be dealt with; the lighting designer is also responsible for the overall color "atmosphere." For example, soft white lamps might be selected for their excellent rendition of foods and complexions, and yet the pinkish atmosphere created might be found unsuitable for a given dining room.

This and earlier papers[1, 2] record practical aspects of color rendition under available fluorescent lamps, point out fundamental deficiencies and establish a basis for a logical line of colors designed to meet nearly all general lighting requirements. Subsequent to the convention, success has been announced in the completed development of such a simplified line consisting of two colors, a "cool white" (approximately 4500° K) and a "warm white" (approximately 3000° K) meeting with the usual atmospheric requirements for "working" and "social" environments. Each of these colors is made with "standard" phosphors, giving high efficiency with reasonable color rendition, and with "deluxe" phosphors,[2] giving maximum color rendition with reasonable efficiency. These four sources offer a satisfying choice as to efficiency, color rendition and atmosphere for nearly any environment.[†]

With regard to Mr. Strong's questions and comments, we considered all observers expert on foods and complexions. They were able to repeat their preference choice after a lapse of time, indicating a sustained criterion. Our studies were carried out at large scale to minimize the well-known effect of large areas appearing more intense in color than small samples. I do not believe our knowledge in color or in other fields is anywhere near sufficient for any of us to take the "responsibility" to "orient the tastes of people to choose and like that which (we think) promotes their welfare." Rather, I feel we should offer an adequate range and freedom of choice, "let the chips fall where they may."

The mercury lines were omitted in the drawing for clarity, as stated. They were obviously present in all the lamps used in the preference studies, for whatever effect, good or bad, they might have. I agree the light reflected from an object is the product of the spectral character of the source and of the object. However, in these comparisons, the object is the same, hence I do not see what advantage would accrue by multiplying each source curve by a constant function, the spectral character of the object. Mr. Strong's point that a source to compliment one object, *e.g.*, coffee, may not be best for another, *e.g.*, lettuce, was discussed. I do not agree that the "daylight lamp fails to give color satisfaction mainly because of the mercury lines" — the lack of red and surplus of blue from the phosphor are greater factors. However, both of his latter comments have to do primarily with color contrast, which is minimized by sources with narrow spectral characteristics, and emphasized by broader (or sometimes by separated) spectral bands. As a test, may I suggest Mr. Strong compare a bouquet of red roses — (nature provides maximal color contrasts between flowers and leaves) — under the new deluxe cool white — and daylight fluorescent, or any other source. I believe he will agree fluorescent no longer need "limp around on (color) crutches."

Mr. Twitchell's experience with daylight fluorescent on furs does not check with our observations of general practice throughout the country. For example, in a survey of the "fur district" in New York City, we found a great majority (approximately 90 per cent) using daylight fluorescent. It was this observation that led us to study furs as an exception to the "preference rule" which Mr. Twitchell's choice of warm tint and filament would support. Our data are for a number of observers, both fur experts and laymen, viewing many types of furs under conditions completely controllable as to color of source and environment. Mr. Twitchell reports experience with one store, with a fixed color scheme and where usually the opinions of at most a few individuals are controlling. Such opinions may be affected by many factors, including the color of lighting used by one's competitor, by the appearance of the model's complexion, by the background of wood paneling, furniture, etc., or by the overall atmosphere of the room. I believe Mr. Twitchell will usually find preference for the more blue source when attention is on the furs themselves. The use of filament affects both color and the "sheen" or "texture" and may produce an effect not available with a diffuse fluorescent source, regardless of color or spectral character. Hence, to do an outstanding job on furs, one would suggest daylight (or daylight plus blue) fluorescent lamps and filament spots with blue filters to raise the apparent color temperature to the 6,000 to 10,000° Kelvin range. We did view a great number of coats, perhaps 30 or 40. However, space permitted showing data for only a few representative samples in Fig. 10.

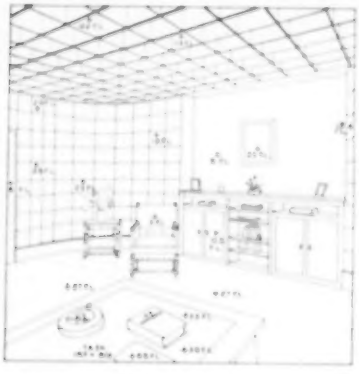
**Author.

†"Color Properties of a Simplified Line of White Fluorescent Lamps." A. C. Barr. ILLUMINATING ENGINEERING, January, 1950.

Lighting a Private Office

LIGHTING OBJECTIVE: To provide louvered lighting for a private office.

Installation in the office of E. C. Hinck, Jr., Illuminating Engineer, Montclair, New Jersey.



General Information: The 18' x 15' x 11' room is decorated as follows:

Walls	— tan wallpaper	—	25% RF
Carpet	— 2-tone tan	—	11% RF
		—	27% RF
Furniture	— bleached oak	—	35% RF
Desk Top	— bleached oak	—	39% RF

Installation: Twenty-eight 96-inch T8 4500 K slimline fluorescent lamps on wiring channel (Fullerton "striplites"), one 72-inch T8, and one 42-inch T6 are mounted end-to-end on 12-inch centers, 12 inches above large wooden louvers. The louvers are formed by 12-inch boards suspended in a grid with 12" x 14" cells. Elevation of bottom of louvers is 9 feet above the floor.

Average illumination throughout the room is 80 footcandles.

Brightnesses are indicated in the drawing at the left.

Lighting data submitted by W. Greenwood, Public Service Electric and Gas Company, Newark, New Jersey, as an illustration of good lighting practice and to aid in the design of similar installations.

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Low Temperature Performance of Krypton-Filled Fluorescent Lamps

By GEORGE S. EVANS

Lamp performance as a function of ambient temperature is different for krypton-filled fluorescent lamps as compared to argon-filled lamps, particularly at the lower ambient temperatures. Lamp operating parameters such as lumen output, lamp watts, lamp volts, bulb temperature, and warm-up and stabilization time are given for a temperature range of 0° F to 110° F. The different types of lamps are compared for starting characteristics as a function of ambient temperature using a testing technique which eliminates the variability of starter switches. Lamps included are the 60" T17 with both argon and krypton fill-gas, the 33" T12 with both krypton and a special krypton-neon mixture, and the 24" T12 argon-filled lamp. The data presented should be of interest to lamp design and application engineers.

THE USE OF krypton as a fill-gas for fluorescent lamps makes possible the attainment of higher lamp efficiencies than obtained with argon.[1,2] The performance characteristics of krypton-filled fluorescent lamps at low ambient temperatures are different from those of argon-filled lamps, however, and consideration must be given to these differences in lamp design and application. Investigations of the effect of ambient temperature on the performance of argon-filled lamps have been described.[3]

The tests reported in this paper are intended to provide similar data for krypton-filled lamps.

Description of Tests and Equipment

The tests were of two types determining the effect of ambient temperature on lamp operation and on lamp starting.

Lamp Operating Tests. — Lamp operating tests consisted of burning the various lamps in still air, one at a time, at different ambient temperatures until measurements made on the lamp indicated equilibrium conditions were obtained. Seasoned lamps were used to eliminate the possibility of lamp changes during the tests. Measurements were made on lamp operating volts, current, watts, light output and bulb temperature at various intervals from the time the lamp was turned on until equilibrium was reached. Observation was made of instability of light output and the period of burning required for such instability to disappear. The lamp types tested were:

1. 60-inch T17, filled with argon gas. This is the standard 100-watt T17 lamp.

2. 60-inch T17, filled with krypton gas. This is the standard 85-watt T-17 lamp.

3. 33-inch T12, filled with krypton gas. This is the standard 25-watt T12 lamp.

4. 33-inch T12, filled with a krypton-neon gas mixture. The mixture contained 25 per cent neon by volume, the remainder being krypton gas. This is an experimental lamp which operates at approximately 25 watts on the 25-watt T12 ballast.

5. 24-inch T12, filled with argon gas. This is the standard 20-watt T12 lamp.

Results in each lamp group were consistent thereby eliminating the need for large numbers of lamps of each type to establish the patterns of test data.

The tests were made in a gravity-cooled walk-in refrigerator having internal dimensions 11 feet by 11 feet by 9 feet. The temperature could be varied from −5° F to 120° F, with radiant heaters (shielded from the lamp under test) being used to obtain temperatures above room temperature. The temperature selected for a particular test run was maintained within plus or minus two degrees. Temperature distribution throughout the box was uniform to within two degrees. Box temperature was indicated and controlled by means of a thermocouple located six to eight inches from the center of the lamp and at the lamp mounting height from the box floor.

The lamps were mounted in free space three feet above the floor, in the approximate center of the floor area. A photocell corrected to eye sensitivity was used with a linear amplifier to indicate relative light output under different test conditions. The distance from lamp to photocell was selected so

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Author: Westinghouse Electric Corp., Bloomfield, N. J.

that the cell viewed the entire lamp length. The photocell-amplifier unit, mounted in the refrigerator wall on the same level as the lamps, operated at a temperature substantially independent of the internal refrigerator temperature. Means were provided to check for possible change in photocell-amplifier calibration throughout the tests. Surfaces of the interior of the refrigerator viewed by the photocell were covered with black velvet to provide a constant background.

The lamps were operated on a regulated 118-volt a-c power supply having good wave shape, with inductive-type ballasts specially selected for proper operating characteristics. The ballasts were mounted inside the refrigerator. Measurements on the lamps were made in accordance with recommended practice, the measuring instruments being kept outside the refrigerator. The lamp bulb-wall temperature was measured at the middle of lamp length, on the underside, as this position was found to be the coolest part of the bulb. A copper-constantan thermocouple of twenty mil diameter wire was used, the junction being firmly held against the glass surface by means insuring good contact with negligible heat drain from the junction. All lamps being tested were kept inside the refrigerator throughout the tests to insure equilibrium bulb temperature conditions.

Lamp Starting Tests. — The starting tests are intended to compare the several lamp types as to ease of starting at different ambient temperatures. A test technique was developed to permit this comparison without introducing complicating factors involved when starter switches are used. Generally, lamp starting tests with glow switches are as much a test of the quality and design of the glow switches as of the lamps themselves. Direct lamp comparison was obtained with the test described below.

The lamps were mounted in the refrigerator, as in the operating tests, but with a grounded sheet of metal adjacent to the lamp. This metal piece, representing the metal of a fixture, extended the full length of the lamp and was of a width equal to twice the lamp diameter. The lamp sockets, a standard type for the particular lamp being tested, projected through the metal piece as they would in a fixture, thereby determining the extent of separation between the lamp and adjacent metal. One filament of the lamp under test was preheated to obtain end-glow; the other filament was not heated in order to keep the circuit as simple as possible. As described so far, the lamp to be tested is in a metal fixture, with a heated cathode, waiting for a voltage pulse to start it. Except that only one cathode is heated, this is the same as having a lamp preheated through a glow-switch, just prior to the opening of the glow-switch contacts.

When the contacts of a glow-switch open, a voltage pulse is imposed on the lamp. The amplitude, wave-shape, and duration of this pulse is determined by several factors such as switch design, circuit connections, and the value of preheat current at the time the contacts open. The pulse is directional, in that one preheated filament acts as cathode and the other as anode in starting the lamp.

Square-wave direct current pulses, which could be varied both in amplitude and pulse-width, were applied to the lamp to simulate the voltage kicks from glow-switch starters. The preheated filament was made the cathode. The pulse circuit had sufficient energy that if the lamp started, the lamp current would rise to a value such that the typical low voltage discharge would be obtained. This was determined by observing, on an oscilloscope, that the pulse voltage fell from the high applied value to a low lamp voltage drop.

For a selected pulse width, the amplitude of the pulse was slowly raised as the pulses were applied to the lamp, until it was observed that lamp starting was being obtained just before the end of the voltage pulse. The pulse voltage so determined was called the lamp starting voltage. The shapes of the voltage pulses are given in Fig. 1.

Zero-hour lamps of the types listed above, were tested at various ambient temperatures and with

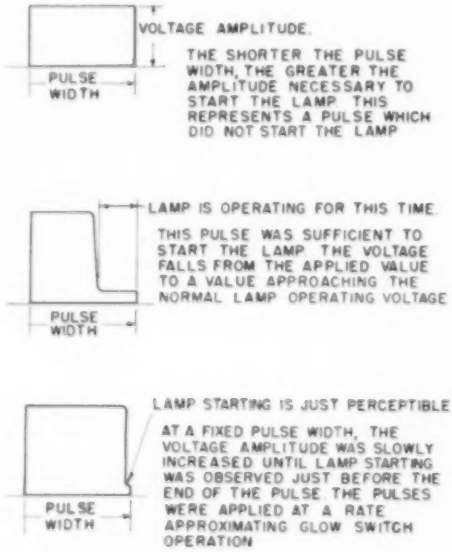
VOLTAGE AMPLITUDE
PULSE WIDTH
THE SHORTER THE PULSE WIDTH, THE GREATER THE AMPLITUDE NECESSARY TO START THE LAMP. THIS REPRESENTS A PULSE WHICH DID NOT START THE LAMP
LAMP IS OPERATING FOR THIS TIME
THIS PULSE WAS SUFFICIENT TO START THE LAMP. THE VOLTAGE FALLS FROM THE APPLIED VALUE TO A VALUE APPROACHING THE NORMAL LAMP OPERATING VOLTAGE
PULSE WIDTH
LAMP STARTING IS JUST PERCEPTIBLE
AT A FIXED PULSE WIDTH, THE VOLTAGE AMPLITUDE WAS SLOWLY INCREASED UNTIL LAMP STARTING WAS OBSERVED JUST BEFORE THE END OF THE PULSE. THE PULSES WERE APPLIED AT A RATE APPROXIMATING GLOW SWITCH OPERATION
PULSE WIDTH

Figure 1. Voltage pulses obtained in lamp starting tests.

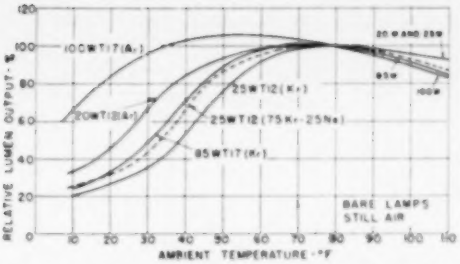

Figure 2. Effect of ambient temperature on relative light output of lamps.

various pulse widths. The lamps were held at the respective temperatures until thermal equilibrium was assured. Results were very consistent among lamps in the groups.

Effect of Ambient Temperature on Equilibrium Values of Light Output, Lamp Watts and Lamp Volts

Fig. 2 presents the relationship between light output of the lamp types tested and the still air ambient temperature in which the lamps were operated. The values shown are for equilibrium conditions, with the lamps operating on inductive ballasts which supply approximately rated watts and current at 80°F and 118 volts input. The two argon-filled lamps are found to maintain their light output at lower ambient temperatures better than do the krypton-filled lamps, with the 100-watt T17 being superior to the 20-watt T12 because of higher lamp loading, *i.e.*, higher arc watts input per square inch of bulb surface area. The 25-watt T12 lamp filled with 75% Kr - 25% Ne maintains light output better than the standard 25-watt T12 lamp, but not as well as the argon-filled 20-watt T12.

The light output of a fluorescent lamp is a function of the mercury vapor pressure within the lamp, which in turn depends on the bulb-wall temperature. Fig. 3 shows how the bulb-wall temperature of the lamps tested varies with ambient temperature. The argon-filled lamps have almost a linear

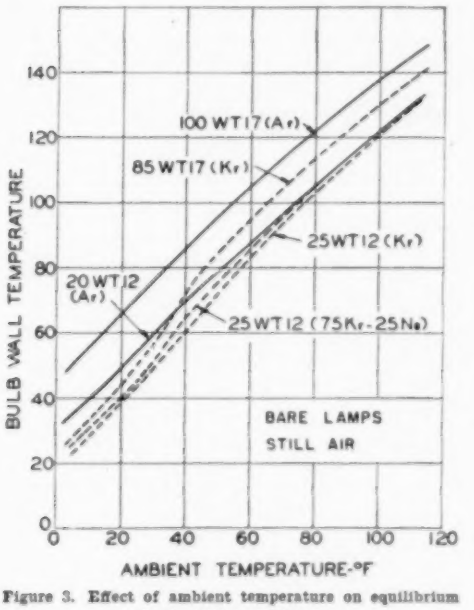

Figure 3. Effect of ambient temperature on equilibrium bulb wall temperature.

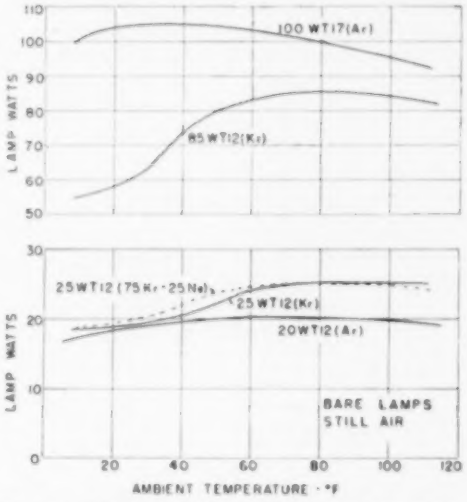

Figure 4. Effect of ambient temperature on lamp watts.

decrease of bulb-wall temperature with decreasing ambient, but the krypton-filled lamps exhibit a more rapid decrease at the lower ambient temperatures.

Fig. 4 shows that the more rapid decrease of bulb-wall temperature of the krypton lamps is due to "unloading" of watts by the lamps at the lower temperatures, in addition to the more familiar factors which affect heat dissipation and therefore the bulb-wall temperature. In other words, while the bulb temperatures of the comparable types are affected similarly by the usual factors determining the rate at which heat is lost, the krypton lamps do not maintain as constant a wattage as do the argon lamps, and are therefore more adversely affected by lower ambient temperatures.

The effect of ambient temperature on lamp voltage is given in Fig. 5. The rapid decrease of watt-

age of the krypton lamps is due to the fall-off of voltage shown by these curves. The 25-watt T12 lamp containing 75% Kr - 25% Ne, for example, shows better maintenance of voltage than does the 25-watt T12 lamp filled with 100 per cent krypton, and therefore has better maintenance of lamp watts, bulb temperature, and light output at the lower ambient temperatures.

The voltage curves of Fig. 5 are of interest in another connection. Some starter types are available in which the contacts are closed to start preheat, are opened by preheat current, then held open by an auxiliary heater connected in parallel with the lamp. Such starters may not be satisfactory with the krypton-filled lamps, depending upon the ambient temperature, due to the reduction of lamp voltages at the lower ambient temperatures. A starter of this type used with the 25-watt T12

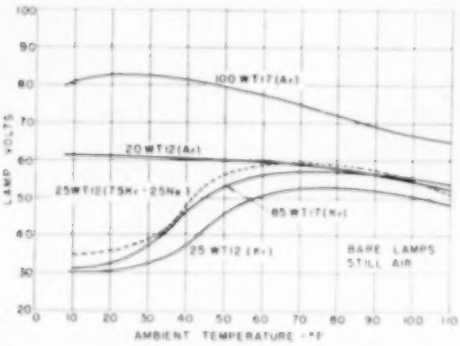

Figure 5. Effect of ambient temperature on lamp voltage.

krypton-filled lamp at approximately 50° F ambient, for example, was found to recycle at 30-second intervals because the reduced lamp voltage at 50° F did not provide enough energy to the auxiliary heater to keep the contacts open after the lamp had started.

The 100-watt T17 and 85-watt T17 lamps on the lead side of the ordinary 100-watt T17 two-lamp ballast exhibit performance characteristics at low temperatures which are different from those given for inductive ballast operation. This is due to the difference in regulation characteristics between the lead and lag sides. For the 85-watt T17, the lamp watts, and light output fall off faster on the lead side than on the lag side as the ambient temperature is reduced. In contrast, lamp watts, and light output of the 100-watt T17 are maintained better on the lead side than on the lag side, with lowered ambient temperatures.

From light output, lamps watts, lamp volts, and

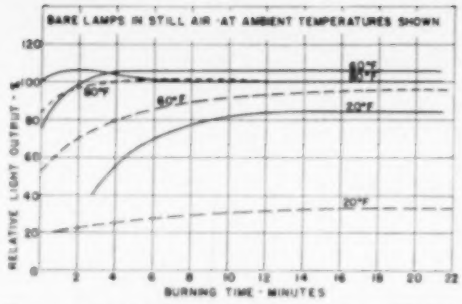

Figure 6. Burning time required to reach equilibrium. Solid curves, 100-watt T17 (Ar) lamp. Dashed curves, 85-watt T17 (Kr) lamp. Light output is expressed as a percentage of equilibrium values of respective lamp types at 80° F ambient.

bulb temperature given as a function of ambient temperature in Figs. 2-5, the fundamental relationships of light output, lamp watts, and lamp volts, to bulb temperature can be determined. If the bulb temperature can be measured, these relationships will permit the determination of light output, lamp watts, and lamp volts for various degrees of drafts, shielding, etc., which result in bulb temperatures within the range given in Fig. 3.

Comparison of Burning Times Required to Reach Equilibrium

Fig. 6 expresses the relative rates of lamp warm-up to equilibrium, comparing the 100-watt T17 and 85-watt T17 types. The curves indicate that the 100-watt T17 lamp reaches equilibrium quicker than does the 85-watt T17 lamp. Misleading comparisons between the two types of lamps in installations have resulted from not permitting the lamps to reach equilibrium before making light output observations.

Fig. 7 presents similar data for the 25-watt T12

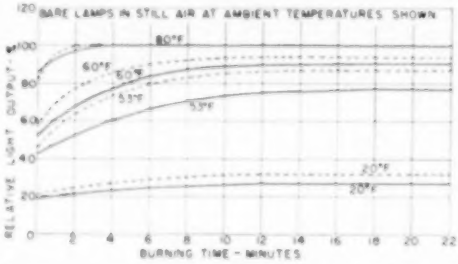

Figure 7. Burning time required to reach equilibrium. Solid curves, 25-watt T12 (Kr) Lamp. Dashed curves, 25-watt T12 (75% Kr - 25% Ne) lamp. Light output is expressed as a percentage of equilibrium values of respective lamp types at 80° F ambient.

krypton-filled lamp and the 25-watt T12 lamp containing 75% Kr - 25% Ne. The use of 75% Kr - 25% Ne improves the warm-up characteristic but not to the extent of being equivalent to argon. The 53°F and 60°F curves correspond to the range of ambient temperature at which light output is beginning to be affected seriously by lower ambient temperature. (Fig. 2).

Effect of Ambient Temperature on Stability of Light Output

A pronounced difference exists between krypton-filled and argon-filled fluorescent lamps at lower ambient temperatures with regard to stability of light output. The krypton-filled lamps show a greater tendency to have unstable light output,

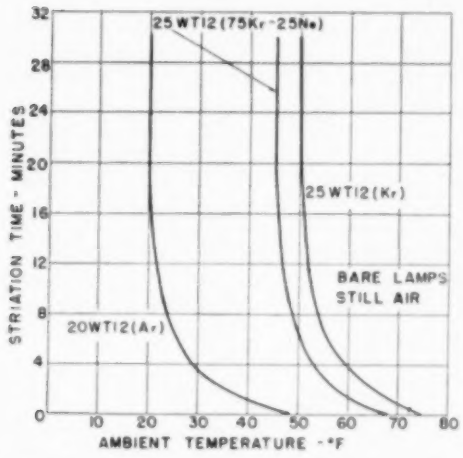

Figure 8. Relation of time of existence of striations to ambient temperature.

causing the lamp to have an appearance of "shivering." This is due to moving striations in the gas discharge. Although the argon-filled lamps are not so noticeably unstable, it is believed that striations are responsible for the instability in this gas also. Fig. 8 presents data on the time interval during which striations will exist, from the time that the lamp is turned on at a given ambient temperature, to the time that striations are no longer perceptible to the eye. The straitions are more pronounced when the lamp is first turned on, becoming gradually fainter as the bulb-wall temperature rises, until at some bulb-wall temperature they become imperceptible. The approximate critical bulb-temperatures above which striations do not occur are shown by the intersection of the curves with the abscissa of Fig. 8. At ambient temperatures above the bulb-temperature that is critical for the respective lamp type, striations will not be observed at all; at ambient temperatures below the critical bulb temperature, striations will be observed until the bulb temperature has risen above the critical value. Examination of Fig. 8 indicates that the type of fill-gas influences not only the rate of bulb temperature rise, but also the critical bulb temperature. The 25-watt T12 lamp with the 75% Kr - 25% Ne gas mixture is better than the 100 per cent krypton-filled 25-watt T12 lamp, but both are significantly inferior to the 20-watt T12 argon-filled lamp. The 100-watt T17 lamps were not observed to striate, whereas the 85-watt T17 lamps in some cases were observed to striate at ambient temperatures of approximately 35°F. It appears that the tendency to striate is dependent on type of gas fill, lamp loading, and possibly fill-gas pressure, but no quantitative evaluation of these factors can be offered at this time.

Since the period of existence of striations at the lower ambient temperatures depends on bulb-wall temperature, drafts will prolong the striation period. It is therefore obvious that enclosed fixtures should be used with krypton-filled lamps subject to operation at the lower ambient temperatures if striations are objectionable.

Lamp Starting as a Function of Ambient Temperature

Lamp starting with glow switches involves many factors hard to control and evaluate. The fundamental processes of initiating gas discharges are complex in themselves; and when such variables are added as are introduced by differences in glow switch design and quality, circuit connections and components, and effect of adjacent objects and ambient conditions, it is almost impossible to achieve a standard test condition whereby lamps and lamp types can be compared. For example, the glow switches of any manufacturer will vary in quality from time to time. Further, the characteristics of a glow switch made by one manufacturer may be quite different from those of a glow switch of another manufacturer, although the switches may carry the same designation and give equivalent performance in the intended application. It was therefore considered necessary in measuring the relative startability of the different lamps as a function of ambient temperature, to develop the starting test previously described. The data secured from this type of starting test must not be interpreted as indicating that one combination of lamp

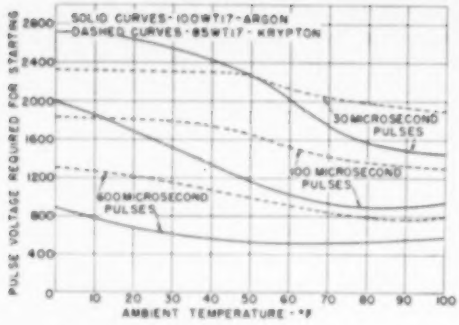
SOLID CURVES - 100%T17 - ARGON
DASHED CURVES - 85%T17 - KRYPTON
30 MICROSECOND PULSES
100 MICROSECOND PULSES
600 MICROSECOND PULSES
PULSE VOLTAGE REQUIRED FOR STARTING
AMBIENT TEMPERATURE - °F

Figure 9. Relative startability of argon and krypton in 60" T17 fluorescent lamps.

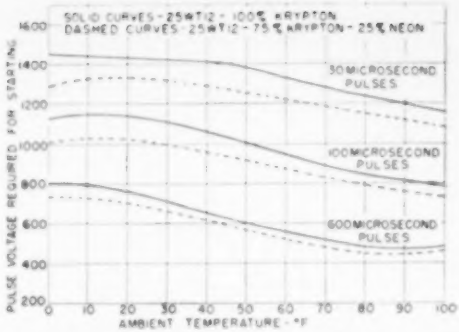
SOLID CURVES - 25%T12 - 100% KRYPTON
DASHED CURVES - 25%T12 - 75% KRYPTON - 25% NEON
30 MICROSECOND PULSES
100 MICROSECOND PULSES
600 MICROSECOND PULSES
PULSE VOLTAGE REQUIRED FOR STARTING
AMBIENT TEMPERATURE - °F

Figure 10. Relative startability of krypton and 75% Kr - 25% Ne in 33" T12 fluorescent lamps.

type, starter, and circuit components will give more reliable starting than a different combination of lamp type, starter, and circuit components. For example, the 20-watt T12 lamp is fundamentally easier to start than the 25-watt T12 lamp, yet in applications the starting of both will be equally reliable with proper design of the circuit auxiliaries.

In Fig. 9, argon filled and krypton-filled lamps of the 60" T17 size are compared for relative starting using the pulse-voltage method. Three different pulse-widths are shown to cover the range of pulse-widths secured from glow-switch starters normally used with these lamps. The usual starter will have a pulse-width approximating 600 microseconds. Using the voltage amplitude required to start the lamp as the criteria for startability, the following conclusions will be evident:

1. Starting is greatly affected by the length of time the voltage pulse exists. This is important in starter design.

2. Krypton filled lamps are harder to start than the argon-filled lamps at comparable pulse times and ambient temperatures.

3. Starting of lamps filled with either krypton or argon becomes more difficult at lower ambient temperatures, the effect of lower ambient temperatures being somewhat more severe with argon at the shorter pulse times.

In Fig. 10, krypton and 75% Kr - 25% Ne are compared in the 33" T12 (25-watt T12) lamp. The effect of pulse-width is again seen to be important. The 75% Kr - 25% Ne fill-gas is easier to start than 100 per cent krypton, with the effect of ambient temperature being comparable for the two gases. Data taken on argon-filled 20-watt T12 lamps shows this lamp type to require approximately half the pulse-voltage needed for the krypton-filled 25-watt T12 lamp at comparable pulse-widths and ambient temperatures. This is due to the shorter lamp length as well as to the difference in fill-gas. Again, the effect of lower ambient temperature is found to be more severe with argon than with krypton.

The data given in Fig. 9 and Fig. 10 were taken with the filament acting as cathode heated to secure end-glow, and with an adjacent grounded metal strip. The voltages required with a filament heated to a temperature just below the end-glow temperature are a little higher than with end-glow present. With both the filaments end-glowing, the voltages are a little lower, this having the effect of a slightly shorter lamp. Without the grounded strip, the required voltages are about 30 per cent higher, thus confirming previous experience that more reliable starting of lamps is obtained in grounded metal fixtures than in non-grounded or non-metallic types. The effect of fill-gas pressure on values obtained in this type of test is also consistent with previous knowledge — the lower the pressure, the lower the required voltage. It is believed that this test technique will prove to be a useful tool in developing new lamps or improving the starting characteristics of the present types.

Behavior of Special Gas Mixtures at Low Ambient Temperatures

In a companion paper by George Meister and Thomas Heine titled "Low Pressure Mercury Discharges," data are presented on the characteristics of electrical discharges in mercury vapor and certain gas mixtures. It is shown that the use of 75% Kr - 25% Ne (by volume) in conjunction with mercury vapor will result in fluorescent lamp efficiencies equivalent to or better than those obtained in fluorescent lamps with krypton-mercury discharges.

Data have been presented in this paper to compare the effect of ambient temperature on the 25-

watt T12 lamp with both 100 per cent krypton and 75% Kr - 25% Ne as fill-gases. The 75% Kr - 25% Ne gas, compared to the 100 per cent krypton gas, has the following advantages in the 25-watt T12 lamp as summarized from the data previously given:

1. Light output, lamp watts, and lamp volts are maintained better at lower ambient temperatures.

2. Lamp warm up is faster and therefore equilibrium operation is obtained sooner.

3. Improvement is obtained in the light instability effect—a lower ambient temperature is permissible and the period of time that light instability will exist is decreased.

4. Lamp starting requirements are less severe.

The 25-watt T12 lamp with 75% Kr - 25% Ne fill-gas will operate at approximately 59 volts, 480 ma and 25 watts on an inductive ballast which operates the standard 25-watt T12 lamp with 100 per cent krypton at the published ratings of 53 volts, 520 ma and 25 watts.

The use of such gas mixtures offers the lamp designer an interesting means of improving the characteristics of present lamp types and of developing new lamps.

In conclusion, the author gratefully acknowledges the assistance given by his associates Herbert C. Walton and Thomas Heine. He also wishes to thank Mr. Donald Dickson of the Research Department who developed the lamp starting test techniques and made the starting test measurements.

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DISCUSSION

C. L. AMICK*: All of the papers presented at this year's conference have been fine contributions, and Mr. Evan's paper is no exception.

I would like to add some data which resulted from measurements of 85- and 100-watt fluorescent lamps by Mr. L. R. Keiffer of Nela Park. Mr. Keiffer tested the light output and starting reliability of these lamps in closed-end, open-bottom, industrial fixtures, and the results, as would be expected, are somewhat different from those presented by Mr. Evans who tested in free space.

The industrial reflector, of course, tends to hold the heat around the lamps. This means that the light output of the 100-watt argon lamp is even better maintained under low-temperature conditions than when the lamps are out in the open. As a matter of fact, the relative light output when using such a reflector is 10 per cent higher at 40° F. than at the 80° rating point. At about 10-15° the output is the same as at 80°, and even at minus 20° the relative output is still 45 per cent.

Mr. Keiffer's tests on the 85-watt krypton lamp showed relatively constant light output from 80 to 60° F., but below 60° the decrease is rapid, falling to 20 per cent at 20°. At 35° the light output of 100-watt lamps in industrial reflectors is five times that obtained with 85-watt lamps. The obvious conclusion: don't use 85-watt lamps at temperatures much below 50°.

Little difficulty was encountered in starting 100-watt lamps down to temperatures as low as minus 20° when FS-64 thermal switch starters were employed. These and other results of Mr. Keiffer's tests are in essential agreement with those reported by Mr. Evans.

E. F. LOWRY*: This very interesting paper emphasizes the fact that the new tools which the illuminating engineer has available are the tools of the specialist. Just as the machinist must know not only the proper speed at which to run his lathe but also the proper shape of cutting edge for the particular kind of metal with which he is working, the illuminating engineer needs to know not only the wattage, lumen output and rated life of a lamp but also the way in which that lamp will perform under various ambient conditions.

This paper definitely points out some of the factors which should govern the selection of krypton filled fluorescent lamps over those filled with argon. There are certain situations where the krypton filled lamp has distinct merit. In others it has some definite disadvantages. For example, the 85-watt krypton lamps has a better efficiency than the 100-watt argon filled lamp at ambient temperatures above 80°F, but conversely has a slow warm up time and at temperatures below 80°F does not deliver as high a lumen output as does the 100-watt lamp. This latter situation also applies when the bulbs are cooled by air currents.

The krypton lamps are harder starting than the argon lamps but this situation has been largely taken care of by redesign of the starter switches to furnish a sharper break with a higher pulse voltage.

In a paper presented last year at the I.E.S. Boston Conference, Mr. Found reported that the increased efficiencies of krypton filled lamps were obtained in important amounts only at high lamp loadings. Mr. Evans does not seem to find that effect. Is there an explanation for this apparent discrepancy?

It is stated in this paper that the "more rapid decrease of bulb-wall temperatures of the krypton lamps is due to 'unloading' of watts by the lamps at the lower temperatures." An explanation of the term "unloading" together with a discussion of the mechanism by which this "unloading" takes place would serve to clarify the situation considerably.

Referring again to the previous paper by Mr. Found and his explanation of the reason for the higher efficien-

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*Sylvania Electric Products Inc., Salem, Mass.

cies obtainable with krypton filled lamps, one would expect that krypton-argon mixtures would result in intermediate efficiencies. In this paper as well as in the companion paper by Mr. Meister improved starting and less temperature dependence over the lamps filled with krypton alone are apparent. However, the reasons for attainment of efficiencies equal to those of the krypton lamps are not apparent. Can Mr. Evans explain this anomalous effect?

E. H. Salter*: Mr. Evans has done a fine job of presenting his findings on the operating characteristics of krypton-filled fluorescent lamps.

At E.T.L. similar investigations have been made of commercially available krypton-filled lamps for the purpose of obtaining data for use in the interpretation of factory test results, where testing cannot always be carried out under controlled ambient air temperatures. Our investigations of the 25-watt and 85-watt lamps have yielded results which are in general quite comparable with those presented by Mr. Evans. Bulb wall temperatures as measured at E.T.L. were somewhat higher than reports by Mr. Evans but this probably is due to our measurements being made on the side of the tube while Evans made his measurements on the underside.

Evans' findings of more severe starting requirements for the krypton-filled lamps is borne out in some testing which we have done in determining ease of starting from preheated cathodes. A circuit was arranged to open the starter circuit always at the same point on the voltage wave. 100-watt argon-filled lamps were found to start readily with a single switch opening when the ballast was operated at 80 per cent rated voltage or less. Similar tests with the 85-watt krypton-filled lamp did not start the lamp though ballast voltages were pushed up to 125 per cent rated. Both types of lamp started readily, however, in the conventional operating circuits.

E. H. Raddin**: The author has presented much valuable data which should influence the choice of fluorescent light sources for use in low temperature applications. Obviously, for operation at 50°F and below, the 85-watt T-17 krypton lamp loses its advantage in operating efficiency over the 100-watt T-17 argon lamp. For that matter, fluorescent lighting for low temperature operations is seldom advantageous in consideration of the lower lumens which result.

Several years ago we ran numerous and lengthy tests on 40-watt T-12 fluorescent lamps which showed that low voltage supply which so often occurs greatly affected lamp starting ability at low temperatures. Starter operation at sub-freezing temperatures was also found to be unstable as was stated by the author.

Serious as these difficulties appear, however, we must remember that this problem of low temperature operation will not occur very often in normal practice as this type of lamp is generally used as an industrial light source. When so used, the ambient temperature is usually 70-80°F or higher. This ambient temperature is further increased in an industrial fixture by an additional 10° to 20°. It is important that we emphasize this because at ambient temperatures above 80°F, the 85-watt krypton lamp further extends its advantage in efficiency over the 100-watt argon lamp.

Trouble experienced in starting both the 25-watt and the 85-watt krypton lamps has created some unfavorable consumer reaction to these lamps. This criticism has in most cases been unjustified because in such cases it was caused by use of improper starter switches. The 25-watt lamp will not start dependably on a 20-watt starter, nor will the 85-watt lamp start dependably on the 100-watt starter. Proper starters are now available and produce satisfactory starting. We believe they are all part of the problem and solution so well handled by the author.

The use of neon, a lower cost gas, mixed with krypton should be an economic contribution to the manufacturer and at the same time produce a lamp of better performance in several ways.

We should like to inquire, however, if neon is used in the quantities designated, how much the color of the lamp is changed.

George S. Evans†: I would first like to thank Messrs. Amick, Raddin, Salter and Dr. Lowry for their compliments on the paper.

Mr. Amick's discussion adds further information on the performance of the subject lamps in fixtures. His data are in agreement with those in the paper, and verify the conclusion that 85-watt lamps should not be used at low temperatures.

It is gratifying to know that the E.T.L. tests reported by Mr. Salter yielded results comparable to those obtained in our tests.

Mr. Raddin's comments on lamp starting are well founded. Although it was known that krypton-filled lamps were harder to start than similar argon-filled lamps, laboratory tests indicated that available starters normally would be satisfactory to use. However, field experience showed that various combinations of marginal conditions which resulted in unreliable starting occurred frequently enough that new starters had to be produced for the krypton lamps. Development of such starters greatly increased our knowledge of the mechanisms of lamp starting, resulting in improvement in the general line of starter types.

In the 25WT12 lamp with a fill-gas containing 25 per cent neon, no change in lamp color was found to result from the use of the neon component.

In answer to Dr. Lowry's comments, I do not believe that the data in this paper are inconsistent with the efficiency data for krypton-filled lamps reported by Mr. Found at the Boston Conference in 1948.

The paper shows that the wattage of krypton-filled lamps decreases rapidly with ambient temperature at ambient temperatures below 50°F (Figure 4). In Figure 5 it is shown that lamp voltage shows a similar decrease. Probe measurements show this effect to be due to reduction in potential gradient in the plasma of the discharge. The mechanism of this is not sufficiently known to permit offering a theory explaining it.

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**Champion Lamp Works, Lynn, Mass.
†Author

Dr. Lowry's comment on efficiencies obtained with krypton-argon mixtures perhaps applies more to Mr. Meister's paper "Low Pressure Mercury Discharges." There it was shown (Fig. 4) that at 2 mm fill gas pressure the efficiency of 2537 Å production for a constant current is a maximum for a 50-50 mixture of argon-krypton.

Thus for lamps having equal loading and equal losses such as cathode losses, the 50-50 mixture would give higher lamp efficiency than would 100% krypton. In applying this mixture to a given lamp type, such as the 60"T17 lamp, the slightly increased cathode losses and the less favorable lamp loading (as compared to 100% krypton) result in the efficiency of the 50-50 mixture being comparable to that of the 100% krypton.

The Effect of Operating Cycles on Fluorescent Lamp Performance*

by F. J. Vorlander and E. H. Raddin

THEODORE C. SARGENT**: The data given in this paper are useful for commercial purposes in particular, but it is to be hoped that the authors will not drop the three-hour cycle values from their tabulation. Since the three-hour figure has been used for years in comparative studies, it would be helpful to continue the figure so that relative values may be established from time to time between old and new lamps.

The authors state that the curves apply only to lamps manufactured by their company, hence we have no argument with their values.

It is significant that the .5-hour cycle should appear to be the breaking point. Perhaps further study will throw light on the cause for this phenomena. Possibly the new halo phosphate lamps will show somewhat varied test results.

The search for a forced life operation technique for fluorescent is worthwhile and every encouragement should be given for continuance of the study. If such a method can be dependable, it will represent a long step forward in testing procedures.

F. J. VORLANDER†: The authors are still conducting additional tests to further check the findings of the first series of tests to determine whether subsequent tests closely duplicate the originals. In the meantime, the three-hour cycle basis will be continued.

Large one-hour cycle test racks are in use at this time and lamps from similar manufacturing runs are being checked on one-hour and three-hour cycles. This will provide four similar tests upon which to base the conclusion as to the advisability of one-hour or three-hour cycles for testing.

In the event one-hour cycles are found practical, as expected, there seems little reason to continue three-hour cycle tests merely because that had been past procedure. It must be remembered that in most instances, lamp life is now rated on three-hour cycles rather than three, six and twelve-hour. Reducing the cycle period does reduce manufacturing test time and costs and facilitates more rapid advancement of new developments.

More recent data, as a result of continuing the operation of the lamps on which the paper was based, is rather startling. The improved beryllium lamps of the long life construction cathodes have now exceeded 5500 hours on one-hour burning cycles with only 55 per cent failures. Similar lamps on four-hour cycles have exceeded 6000 hours with 5 per cent failures. The new halo phosphate lamps have performed even better with no failures occurring at 5000 hours for the half-hour cycle, 5000 hours for the four-hour cycle, and 6500 hours for the continuous (300-hour) cycle. When these tests are completed, further comparison will be drawn.

*ILLUMINATING ENGINEERING, January, 1950, page 21.
**Sylvania Electric Products Inc., Salem, Mass.
†Author.

Specially Designed Fluorescent Fixtures in Super-Market

The fast-growing Houston, Texas super-market — J. Weingarten, Inc.—is "selling from the ceiling" with open-type slimline fluorescent fixtures, specially designed for mass lighting of large areas. Photo courtesy of Leader Electric Co., Chicago, Ill.

DISCUSSION

Technique of Lighting Generating Stations

Discussion by C. E. Egeler of the Paper "Technique of Lighting Generating Stations" by H. F. Carroll and W. B. Morton (pages 93 and 94 February issue of ILLUMINATING ENGINEERING) referred to slides shown by Mr. Egeler with his discussion, for which illustrations were received too late for publication with the discussion. The charts and installations illustrating Mr. Egeler's discussion are shown below.

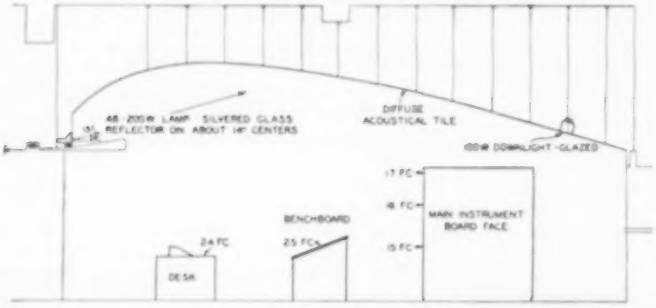


Figure 1. Lighting arrangement employing specially contoured ceiling at TVA Fontana plant control room. (Slide 1)

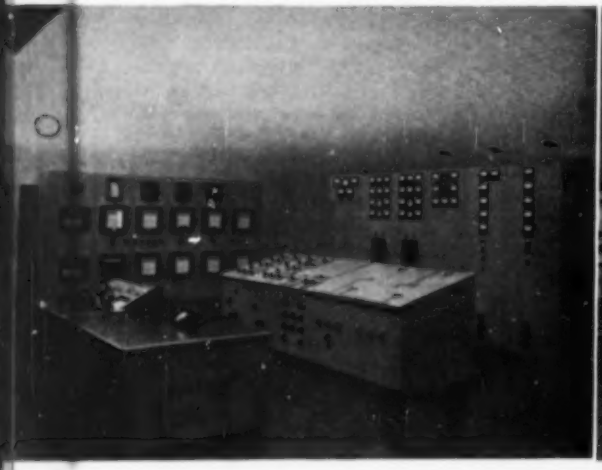


Figure 2. (Left) Lighted appearance of Fontana control room. (Slide 2) Figure 3. (Right) Control room illuminated by Fluorescent lamp units with ribbed glass covers. (Slide 3)

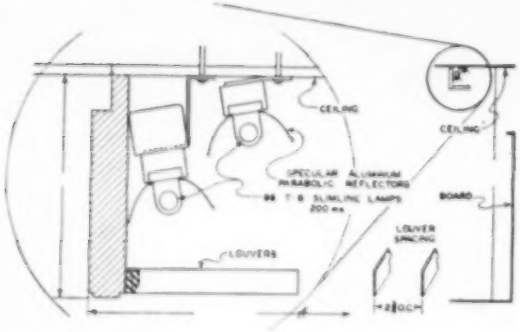


Figure 4. Slimline fluorescent lamps in polished metal parabolic troughs for control board lighting. (Slide 6)

Recommended Practice of Library Lighting

Prepared by the Committee on Library Lighting of the Illuminating Engineering Society*

Foreword

This first "Recommended Practice of Library Lighting" was developed by the I.E.S. Library Lighting Committee which was formed in July, 1946 following requests for a study of library lighting from the American Library Association and architects specializing in library design.

LIBRARY LIGHTING COMMITTEE
J. M. Ketch, *Chairman*
H. A. Cook
E. M. Fahey
J. H. Fedeler
Francis Keally
R. R. Wylie

1. Introduction

(a) This Practice considers lighting for both public and institutional libraries; recognition is given to (1) the possible wide range in the ages and educational levels of the library visitors, (2) the varying conditions of eyesight found within those groups, and (3) the varieties of reading materials that are currently used. Techniques are discussed for lighting high-ceiling areas, both decorated and plain, and also for some of the new modular designs which have relatively low ceilings.

(b) Many of the libraries now in use were designed with as much emphasis to the architectural features of the building as a public monument as to the utilization of the building for library purposes. The modern library is not merely a storehouse for books and periodicals; it is aggressively educational with facilities designed to make available a broad educational program to the public in all walks of life. Some of the new libraries have rooms for lectures, demonstrations, and seminars; facilities for projecting still or motion pictures; and sound-conditioned rooms where musical records can be played. Study rooms, carrels,** and research aids are provided as well as special rooms and display cases for showing rare books and historical collections.

(c) This report (1) recommends lighting practices employing modern sources and techniques for new libraries being designed and (2) suggests methods whereby present libraries now inadequately lighted can bring their lighting standards up to those needed if they are to fulfill the modern expanded educational function. The shortcomings of many present-day lighting installations include:

(1) Illumination levels below those needed for efficient and comfortable reading.

(2) The major dependence upon table lamps for reading purposes.

(3) Dark furniture and interior finishes which produce uncomfortable brightness differences with the reading task.

(4) Reading tables with glossy tops which create reflected glare, especially from table lamps.

(5) Glaring lighting units.

(6) Stack lighting with bare or inadequately shielded lamps. The lamps are glaring and the amount of illumination is inadequate between lamps and on the bottom shelves.

2. Analysis of Seeing Tasks

2.1—*Reading*

2.1.1—*General*—Reading is by far the visual task performed most often in a library. In the recommendation of environmental conditions and footcandles for optimum reading efficiency and comfort, three factors capable of very wide variation must be taken into account: (1) the condition of the reader's eyesight, (2) the character of the reading material, and (3) the reader's intensity and purpose. An additional factor is the angle between the page and the reader's line of vision. (See Appendix A for a discussion of reading racks.)

2.1.2—*Condition of Eyesight*—Public libraries serve people of all ages from elementary school children to grandparents. Statistics on the prevalence of defective vision indicate that the percentage of defective vision among children is low, but that it increases in percentage with added years. Statistically, 95 per cent of persons at the age of 70 have defective vision. The optical defects of many persons' eyes can be totally or partially corrected with glasses; some can be helped only. Although good lighting and seeing conditions are desirable for all readers whatever the condition of their eyes, they will be particularly helpful to older persons and others who have subnormal or uncorrected vision.

2.1.3—*Varieties of Reading Tasks*—In any library there will be found a great variety of reading tasks, some easy, others difficult. Typical of easy ones are children's books, and textbooks and novels printed in 10- to 14-point type, well-leaded, on good, white, non-glossy paper. By contrast are newspapers printed in 7-point type, unleaded, on low-contrast, off-white pulp paper; and law books which usually have long paragraphs printed in condensed type. The readability of printed matter depends upon the type size and its contrast with its background; plus factors such as type face, length of lines, spacing between lines, and margin widths. It has been found that two to three times the illumination is needed for pencil work as for average printed matter because of the difference in contrast. It is intended that the lighting levels and environmental conditions recommended be broad enough to compensate for the range and difficulty of the visual tasks enumerated above.

2.1.4—*Intensity and Purpose of Reading*—The third variable is the intensity with which reading is done, or the purpose for which the visitor goes to the library. Some merely browse or select materials for reading elsewhere; college libraries and those designed

*Approved by the Council of the Illuminating Engineering Society November, 1949.

**Carrel — a small enclosure or alcove in the stackroom designed as a place for individual study or reading.

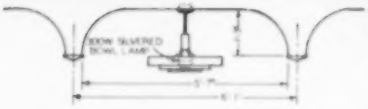


Figure 1. Reference Reading Room, Harvey S. Firestone Memorial Library, Princeton University: (a) (Above) daylight view; (b) (left) detail of coffers.

for professional research, however, are usually used for long periods of research or study. Intensive reading may occur in general reading rooms as well as in carrels or other rooms designed for study purposes. With the exception of children's rooms and areas set aside for browsing, the lighting level and environmental conditions for all reading areas should be selected with the expectation that some intensive study will be carried on there.

2.2—*Offices, etc.* — As a part of every library operation, there must be areas for regular office work and for other visual tasks such as indexing, cataloging, recording, typing and filing. For these, the same kind and amount of illumination employed in commercial offices will be suitable. Recommendations for most of these tasks will be found in the Illuminating Engineering Society's "Recommended Practice of Office Lighting," July, 1947.

2.3—*Book Stacks* — Several factors combine to make the lighting of stacks difficult, especially those to which the public has access. Although people are seldom in the stacks for long periods and their visual tasks are intermittent, they should be able to see all of the titles—top to bottom shelves—easily and quickly. Part of the difficulty in lighting book stacks is caused by the dark book bindings, by the small printing of the titles, and by the usually worn condition of the binding which partially obliterates the title. Another difficulty is caused by the long, narrow stack aisles, and the limitations as to the location of light sources in relation to the vertical surfaces to be lighted. On the other hand, the lighting of book storage and infrequently used stack areas which are used by library employees only can be much simpler; the footcandle requirements are lower, see Table III, and the need for low source brightnesses less urgent.

2.4—*Carrels* — Research and study carrels are reading areas often integrated with, or located close to the stacks.

3. Environmental Factors

3.1—*Brightness Ratios* — Although the eyes function most comfortably and efficiently when all brightnesses within the field of view are uniform, the attainment of such uniformity is not practical for many reasons. It is desirable and practical, however, to reduce extreme brightness differences within the normal field of view; see Table I. (The "central visual field" or seeing task is the book or periodical being read. The "immediately adjacent surface" is in most cases the table on which the book rests.)

TABLE I. — Recommendations for Limits of Brightness Ratios in Libraries

	Ratio
(a) Between the "central visual field," the seeing task, and immediately adjacent surfaces, such as between a book and the table top, with the book as the brighter surface.	1 to 1/3
(b) Between the "central visual field" (book) and the more remote darker surfaces in the "surrounding visual field," such as between book and floor.[1,2]	1 to 1/10
(c) Between the "central visual field" (book) and the more remote brighter surfaces in the "surrounding visual field," such as between book and ceiling.[2]	1 to 10
(d) Between luminaires, or windows, and surfaces adjacent to them in the visual field.	20 to 1

[1]By using light floors (15 to 30% reflectance) ratios of 1 to 1/3 are possible.

[2]These ratios apply for areas of appreciable visual size as measured by the solid visual angle subtended at the eye. Luminous areas on luminaires are generally small in size in this respect. For the brightness limitations of luminaires, see Table V and (d) in Table I.

Figure 2. A public library illuminated by 500-watt indirect luminaires plus two 500-watt direct units through each skylight section. Resultant illumination is 30 to 40 footcandles. Note also the downlights over the attendant's desk at the right.

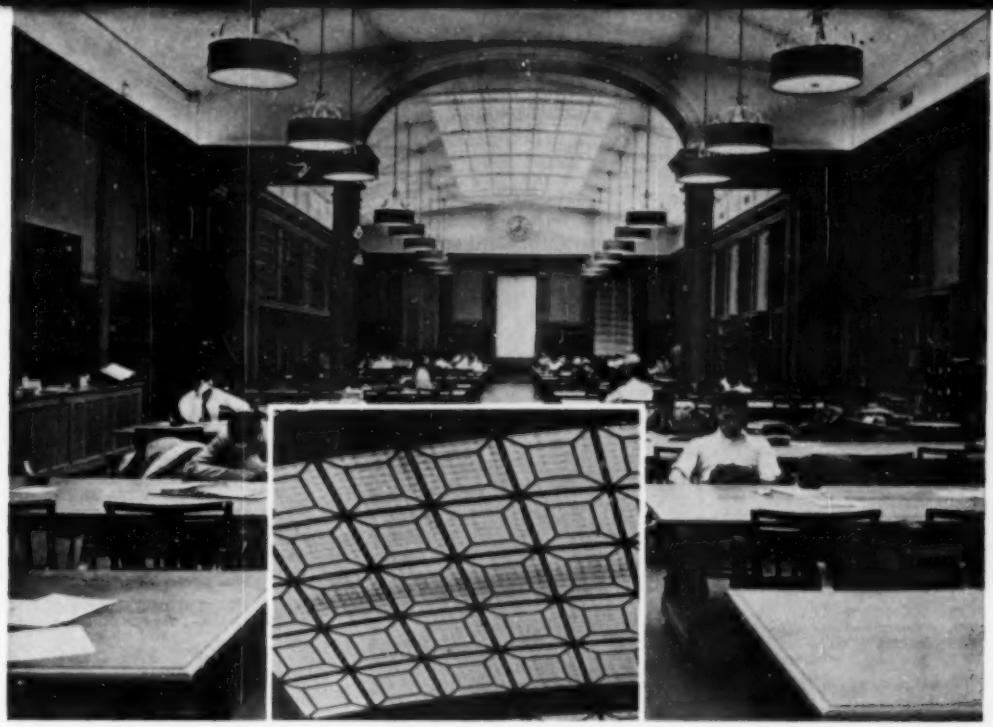


Figure 3. Three lighting techniques are combined to light the reading room of the Baker Library at Harvard University. Slimline lamps in metal reflectors are used over louvers in the former skylights (see insert photo); the large pendant luminaires (redesigned) each contain a 750-watt silver bowl lamp; a wood cornice above bookcases and ornamental paneling conceals cold cathode fluorescent covelighting. The result: 45 footcandles of diffuse illumination.

3.2—*Room Finishes*—(a) The ability to stay within the maximum brightness ratios of Table I will depend to a large degree upon the reflectance values of the room finishes; in conjunction with the lighting, they establish the brightness pattern of any room, and the brightness ratios between the task and other major surfaces within the normal field of view. White ceilings and light-colored walls help to reduce the brightness ratios between luminaires or windows, and surfaces adjacent to them. In addition to creating comfortable brightness ratios, the light colors recommended in Table II aid materially in the utilization of light.

TABLE II.—Recommended Reflectance Values (Per Cent)

Ceilings	80
Walls	50-55 ±5
Desk and Table Tops	30-35 ±5
Furniture	30-35 ±5
Floors	30-40 ±10

(b) In order to avoid annoying reflections, non-glossy surfaces are recommended for ceilings, walls, and table tops. Surface finishes are available for all of these which are acceptably non-glossy; they are easy to clean and collect dirt less rapidly than rough matte finishes.

3.3—*Reading Table and Desk Tops*—(a) In order to keep the brightness ratio between the reading table top and the printed page low, the reflectance of the table top must be higher than the dark-stained tables (10-12 per cent) commonly used. It is recommended that reading table and desk tops have as little specularity or gloss as possible. A highly polished table top will produce reflected images of bright unshaded windows, light sources, or bright ceilings; this reflected glare may be severe enough to offset any advantage gained by better environmental conditions or higher levels of illumination.

(b) Library furniture is now available in the new lighter finishes (24-28 per cent reflectance) as well as the dark, and materials and techniques have been developed for refinishing old furniture to give it the recommended surfaces. Table-grade linoleum is now available in blond-tan and mist-green colors that have 35 per cent reflectance; plastics that are rugged and simple to apply are available in sheet and fabric form; and oak table tops can be bleached and refinished with a non-glossy lacquer.

3.4—*Color*—The use of color in the library interior merits the consideration and advice of a color expert. The reflectance values recommended in Table II can be had in grays or in tints of warm or cool colors. From the standpoint of visual comfort and efficiency, it makes little difference whether the colors be warm, cool, or neutral. In the hands of an expert, however, color has many possibilities; rooms can be made to appear smaller by the use of warm tints, or larger by cool ones. Warm tints can be used in north and east rooms to enliven and warm otherwise drab interiors. Conversely, cool tints are often used in south and west rooms that seem to have an over-abundance of sunshine. In most libraries, color tints will be selected for their aesthetic values and usually by personal preferences.

Figure 4. High-ceilinged library at College of the City of New York. Old fixtures were raised about ten feet and lamp size reduced to eliminate glare, and sixteen 1000-watt downlights installed above ceiling.

TABLE III

	Footcandles Current Recommended Practice
DIFFICULT SEEING TASKS ..... Involving:	50
(a) Discrimination of fine detail (6-8-point type, footnotes, etc., legal reference books with small condensed type; illustrations with fine details, etc.).	
(b) Poor contrast (newspapers, maps; pencil notes, carbon copies, etc.).	
(c) Long periods of time (study; research reading). Illumination of this order is of benefit to those having subnormal eyesight; or for older persons carrying on work or reading of the following classification.	
ORDINARY SEEING TASKS ..... Involving:	30
(a) Discrimination of moderately fine detail (reading 8-12-point type, children's books; general and private office work; active file and mail rooms; cataloging; book repair and binding).	
(b) Better-than-average contrast (reading better magazines and books).	
(c) Intermittent periods of time (browsing; casual reading; book stacks open to the public; card files; check-in and check-out desks).	
CASUAL SEEING TASKS ..... Such as: Conference and reception rooms; stacks closed to the public; stairways and hallways used by the public; washrooms, checkrooms; and other service areas; auditoriums; book storage rooms where labels must be read.	10
SIMPLE SEEING TASKS ..... Such as: Corridors not used by the public; storage rooms involving no reading of labels.	5

The foregoing are recommended with no reference as to the type of illuminant, luminaire or type of lighting system.

4. Recommended Illumination Values

(a) The following footcandle recommendations are consistent with those in the "American Standard Practice for School Lighting," approved by the American Standards Association, September 20, 1948, and those in the "Recommended Practice of Office Lighting" published by the Illuminating Engineering Society in July, 1947. It is apparent that the visual tasks encountered in libraries are comparable in character to those in schools and offices and should, therefore, be consistent with them.

(b) The values listed in Table III are graded according to the difficulty of the visual tasks. These values should be maintained in service through proper cleaning and relamping of lighting equipment, the cleaning of windows, and the maintenance of the reflectance values of room surfaces. Initial values from the artificial lighting system must be greater by a percentage sufficient to compensate for the normal depreciation expected in service. (See Section 6.5)

5. Daylighting

5.1—*Advantages* — Windows serve two valuable purposes from the standpoint of the seeing tasks in the library: **(1)** they admit light into the interior which results in the desirable footcandles for seeing; **(2)** they permit the occupants to look out. The latter has an advantage in addition to the pleasure of looking to the out-of-doors; it permits the reader to focus his eyes for distant vision and thereby relaxes the eye muscles which are under tension from the close vision necessary for reading. It is important, however, that the benefits of daylight through windows be gained without offsetting them by seating arrangements such that large window areas of high brightness are in the field of view.

5.2—*Factors that Affect Natural Lighting* — The distribution and amount of daylight realized in an interior will depend upon many factors: the kind of glass; the number, size, shape and position of the window openings; the ratio of the window height to the room width; the kind of window shading; the amount of daylight outside; the presence of trees and buildings; the brightness pattern of the room; and possibly other conditions. See Appendix B for discussion of these factors. In addition, daylight itself varies greatly through each day and during the year. (See the I.E.S. "Recommended Practice of Daylighting," ILLUMINATING ENGINEERING, February, 1950.)

6. Artificial Lighting

6.1—*Lighting Systems*—(a) Artificial lighting systems are divided into the five following general classes based upon their distribution of light in the upper and lower hemispheres.

TABLE IV

Classification	Distribution of Light from Luminaires Upward	Downward
Indirect	90 -100%	10 - 0%
Semi-indirect	60 - 90%	40 - 10%
General diffusing	40 - 60%	60 - 40%
Semi-direct	10 - 40%	90 - 60%
Direct	0 - 10%	100 - 90%

(b) Systems of all types will have proper application in libraries although some care must be exercised in the selection of the system for reading rooms, offices, and similar areas where people are occupied with difficult visual tasks and are facing in one direction for long periods. The several characteristics presented in Appendix C should be considered also to make the lighting system consistent with the architectural characteristics of the interior.

6.2—*Light Sources*—(a) Judgment must be made also between the two types of light sources—filament and fluorescent lamps—currently used for interior lighting. Considerations of the two sources will include the suitability of the luminaire architecturally, the relative initial cost of the systems, and the cost of lighting per footcandle per year. (See Appendix D.)

(b) As to the suitability of the two illuminants for library purposes, researches indicate that, on an equal footcandle and quality basis, the two illuminants are equal in the visibility, comfort, and readability obtained. Both illuminants are now being used in libraries successfully.

6.3—*Brightness Limitations*— As a guide in luminaire selection for the range of footcandles given in the table of lighting levels (Table III), the brightnesses in Table V are recommended as maximum values both crosswise and lengthwise of the luminaire. Observance of these limits should avoid glare from luminaires under any normal circumstances of installation and room decoration. However, it is recognized that higher values than these have been used without detriment in installations where great care was taken to use light colors and matte finishes in the lower part of the room as well as the upper part, and where the bright areas of luminaires are small. It is recommended that where such conditions permit the use of luminaires of other than the indirect or semi-indirect types, approximately double the values given be accepted as the limits of brightness.

TABLE V

Zone	Recommended Brightness Limits in Footlamberts*
(0° is directly beneath luminaire)	
60° - 90°	225
45° - 60°	450
0° - 45°	1000

*Comparative values in candles per square inch respectively, .5, 1.0, 2.

6.4—*Flexibility*

6.4.1—*General*—It is very desirable to have enough flexibility in a lighting system to make it possible to convert from one footcandle level to another easily and quickly. Because of ever present changes in a library, it might be desirable to quickly convert a general reading room requiring 30 footcandles to a research study room which needs 50; this can be done in many cases without a major revision if properly planned. This requires that the wiring has adequate capacity for the maximum load that will be used. Following are some suggestions that may help to accomplish this desired flexibility.

6.4.2—*Filament Lamp Systems*—300 and 500-watt filament (incandescent) lamps are interchangeable in most luminaires, as are also 750 and 1000-watt. A 300-watt system producing 30 footcandles will produce 50 footcandles with 500-watt lamps. 1000-watt lamps generate 40 per cent more light than 750-watt lamps, making possible a change from 30 to 42 footcandles.

6.4.3—*Fluorescent Systems*—**(a)** Where fluorescent luminaires are spaced intermittently, with the proper space left between, additional equip-

Figure 5. Illustrating use of individual study lamps. Each study table has a lighting unit at the left end, but since tables are end-to-end against the wall they are well lighted from both sides.

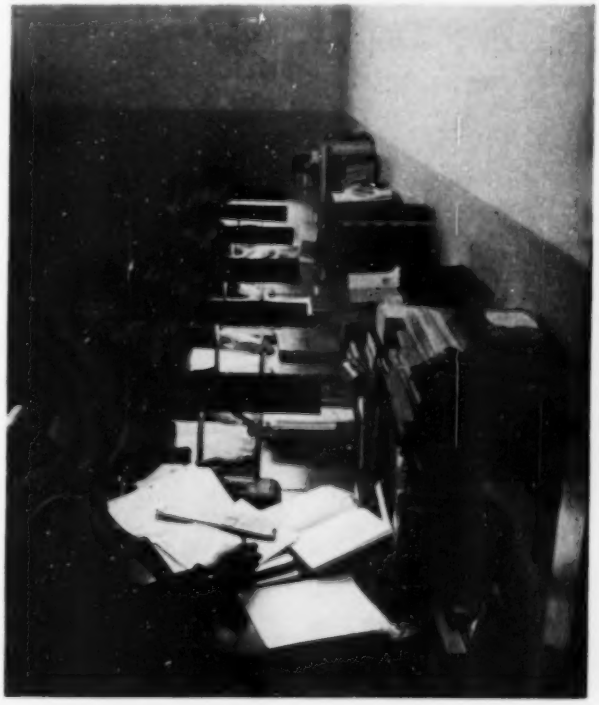


Figure 6. Reading room and stack area, Lamont Library, Harvard University. Troffers for general lighting pins downlights over desks at left and fluorescent stack lighting units.

ment can be installed to make continuous rows.

(b) Where there are continuous rows of luminaires producing 30 footcandles, units can be added at right angles to produce a grid pattern. The luminaires selected should be free from glare when seen either lengthwise or crosswise.

(c) Systems using four-lamp equipment can be installed with pull-chain switches on one two-lamp circuit in each luminaire.

(d) Two-lamp troffers placed at right angles to the normal line of sight can be switched and wired so that continuous-row operation obtains whether one or two lamps are used.

(e) Certain types of fluorescent lamps may be operated at different current densities to obtain different light output values. This would require changes in ballasts.

(f) Ceilings of light with properly spaced and circuited lamps above the control media to produce the desired footcandle changes.

6.5—*Maintenance* — **(a)** Lighting equipment and room surfaces must be well maintained if reasonable efficiency and satisfactory appearance are to be realized. The elements which affect the overall efficiency of a lighting system are the light sources, the luminaires, and the room surfaces. Depreciation of 30 to 50 per cent may be expected depending upon decrease of lamp light-output, atmospheric dust conditions, and design of luminaire in relation to dirt collection.

(b) The output of all light sources diminishes with use, and in many cases it is economical to replace lamps before they finally fail. With planned lamp replacement schedules, savings may be realized by replacing groups of lamps near the end of their useful life rather than individual ones as they burn out. The depreciated lamps are replaced by those of peak performance. If lamps are replaced in alternate luminaires or in alternate rows of luminaires, more constant illumination is maintained.

(c) Lamps and lighting equipment collect dust and dirt which reduce lighting efficiency. The rate of depreciation is dependent upon the atmospheric conditions and the type of lighting system employed. A thorough washing of lighting equipment at least twice a year is economically justified in even the most favorable locations. Under adverse conditions, three or four cleanings per year are needed to achieve the lowest cost operation in terms of footcandle-hours per dollar. With proper cleaning schedules, an increase of at least 25 per cent is often realized in the average maintained value of illumination. Lighting units should be designed with minimum depreciation characteristics and easy maintenance features.

(d) The necessity for cleaning or painting room surfaces is also a function of the amount of dirt contained in the atmosphere. The rate of depreciation is materially reduced where air-conditioning and filter systems are employed, but it is very difficult to eliminate entirely dust and dirt in ordinary library areas. The distribution characteristics of the lighting system also influence the effect of room maintenance, since dirt on room surfaces is more detrimental to an indirect than to a direct lighting system.

(e) A regular program of window cleaning is also essential. Although the accumulation of dirt may not be as rapid in libraries as in factories, the windows require frequent washing to maintain them at reasonable effi-

Figure 7. Research library of a large company illuminated to 50 footcandles by troffers spaced alternately two and four feet apart.

ciency. Dirt on the inside and outside of windows frequently absorbs as much as 50 per cent of the light that might otherwise be admitted to the library area. At the same time, the diffusing effect of such dirt can result in high window brightness and direct glare.

(f) A realistic consideration of these various factors is essential to the efficient operation of the library lighting system. Even the cost of frequent maintenance is more than offset by the value of the additional illumination obtained.

7. Lighting for Specific Areas

7.1—*Reading Rooms*

7.1.1—*Table Lamps*—**(a)** In the past, table lamps, supplemented by low-level general lighting, have been accepted practice for illuminating libraries. Table lamps came into general use when the cost of general lighting was high; in those days, general lighting was commonly used for architectural decoration, for general space illumination, and as a supplement to local table lighting. However, lighting techniques as applied to many kinds of interiors have changed markedly in the past few years with the development of more efficient light sources and improved light controlling equipment. The trend in newer libraries is away from the use of table lamps and toward general lighting of a footcandle level and character suitable for reading purposes.

(b) The reason for this trend is evident when one considers the following shortcomings of conventional lamps:

(1) In order to get light from the lamp, the book must be laid flat.

(2) The reader must often accept the light from an awkward position depending upon where he is seated.

(3) Lamps falling in front of the reader create bad reflected images on glossy book or magazine pages.

(4) The best light is obtained only when close to a lamp. If lamps are widely spaced, some readers have less than enough light.

(5) The multiplicity of reading lamps in a large room creates a cluttered appearance and a continual maintenance problem.

Figure 9. Reading room at Case Institute of Technology, Cleveland, Ohio. Luminous indirect luminaires containing 500-watt filament lamps provide 30 footcandles on the table tops.

(c) For lighting individual study tables in research libraries and other rooms that have a low occupancy factor, individual reading lamps may be suitable as a supplement to a general illumination of medium intensity. It is good practice to have the reading lamps at the left side, or preferably, both sides of the table for the benefit of right or left-handed writers. Furthermore, the units should be so positioned that no reflected images occur in the glossy surfaces laid flat on the table. One such unit was used in officer-training study halls during the war. (See Fig. 5.) In this installation, each study table had a unit at the left end, but since the tables were placed end-to-end against the wall, they were lighted from both sides. Each unit contained two 18-inch 15-watt fluorescent lamps, well-shielded from view. An illumination of 50 footcandles was obtained on the light-finished table tops and this, with the light-colored wall at the table front, completed a comfortable brightness pattern. Modifications of this scheme are possible for tables occupied on both sides, although less easily than for the table occupied on one side only.

7.1.2—*General Lighting*

7.1.2.1—*General*—General reading room illumination of the levels given in Table III will be most acceptable where the time of room occupancy is high enough to justify operating the system all of the time. Lighting engi-

Figure 8. General lighting for this small public library is provided by a rectangular pattern of fluorescent troffers.

Figure 10. (Top) Stack illuminated by 100-watt filament lamps in stack lighting luminaires mounted 7′ 6″ above the floor and 6′ 6″ apart.

Figure 11. (Middle) Short stack aisle used for storage and file purposes illuminated by two four-foot two-lamp semi-direct fluorescent luminaires.

Figure 12. (Bottom) This experimental stack lighting installation in the Cleveland Public Library illustrates the advantage of using reflectors punched with vertical slots to illuminate the upper shelves. The front reflector is parabolic and unslotted, center is ellipsoidal and slotted, rear is slotted parabolic. In foreground note the darkness of upper shelves resulting from reflector cut-off. All units contain four-foot 300 ma slimline fluorescent lamps and are cross-louvered with 25-degree shielding lengthwise.

neers will have two types of rooms to consider: rooms with high ceilings (16 or more feet), and those with low (9-16 feet). Most present libraries of older design have fairly high ceilings and some to be built in the future will undoubtedly be of similar construction. However, in view of increased building costs, and improved methods of ventilation, many new libraries will follow the current trend in schools and office buildings in the use of lower ceilings.

7.1.2.2—*High-Ceiling Rooms* — **(a)** High ceiling rooms that are light in color and plainly or sparsely decorated can be illuminated with indirect, semi-indirect, semi-direct, or large-area, low-brightness direct installations such as artificial skylights and indirectly lighted coffers. See Figs. 1 to 3. General diffusing systems using either light source, e.g., enclosing globes and unshielded fluorescent tubes, are not suitable for reading rooms because the large amount of light at angles near the horizontal becomes a source of direct glare in systems providing the levels of illumination required.

(b) The design of direct lighting installations for reading rooms is more critical than for most other types. Careful attention should be given to the following: minimizing high brightness ratios between luminaires and adjacent ceiling areas; the problems of the spacing distance and mounting height of luminaires; and to the use of luminaires which have an acceptably low brightness in the zone from vertical to 45° to minimize reflected glare from tables and glossy paper. Because of their lower source brightness and higher efficiency, fluorescent lamps will probably be most commonly used. Incandescent lamps are satisfactory if shielded in the 0-45° zone by glazing with a good diffusing material, or by the use of silvered-bowl lamps in diffusing coffers or cavities of high reflectance.

(c) High rooms with dark, decorated, or heavily beamed or coffered ceilings are difficult to light and still retain the original architectural features. In some libraries, the present lighting for reading rooms consists of large decorative chandeliers, which are widely spaced and generally unsuited for the production of the recommended general illumination. It may be possible to convert some of these luminaires into a direct or direct-indirect form that can produce sufficient footcandles comfortably, and still be in keeping with the room decoration. See Figs. 3 and 4. Many units will be impossible to convert and should be replaced.

(d) Some ceilings have cavities where flush, built-in luminaires can be installed. Examples of such architectural features are panels, coffers, and beams which are so spaced that they naturally form the sides or enclosure for direct, louvered, or glazed luminous elements. Such ceiling areas are also natural locations for close-ceiling and suspended luminaires. By intelligently utilizing these architectural elements, general lighting congruous with the decorative plan can usually be provided. Since no two rooms are alike, such installations are preferably planned by a lighting engineer working with an architect.

(e) Where it is not possible, or desirable, to light high-ceiling, heavily decorated rooms as discussed, commercial fluorescent luminaires of the close-ceiling or suspended types should be considered. These can be arranged in continuous or intermittent rows, and in rectangles, squares, or other geometrical patterns. Where the ceiling is generally dark and a good utilization of light at the reading level desired, direct-indirect and semi-direct fluorescent luminaires are indicated.

Enough light reaches the ceiling from units of these types to light the ceiling decorations and to relieve any tunnel-like effect caused by dark ceilings.

7.1.2.3—*Low-Ceiling Rooms*—**(a)** New libraries will require increased flexibility in the utilization of the space for reading rooms, conference areas, stacks, or any of the newer facilities offered by modern library institutions. The lighting designer must accordingly incorporate flexibility features in the lighting to a degree not heretofore necessary.

(b) The lighting of libraries with low ceilings, 9-11 feet, will have to be of a type suitable for reading room purposes without interfering with book stacks. (See Figs. 7, 8 and 9.) Suspended types of luminaires should be high enough to clear stack ranges. In such buildings, the emphasis will undoubtedly be on flush, ceiling-mounted, and short-stem suspended units. Because low-ceiling rooms will provide space above the ceiling for ventilating ducts, pipes and electrical raceways, the location of individual lighting units, or rows, must be co-ordinated with other utilities.

7.2—*Book Storage Areas*

7.2.1—*Wall Shelves*—**(a)** It is common practice to store books on wall shelves in small libraries (*e.g.*, public schools, branch libraries, etc.) and in some areas of large libraries where easy access to certain books is wanted, such as in browsing rooms, children's reading rooms, and specific reading and research departments.

(b) Where good general illumination is present, there will probably be no need for supplementary shelf illumination, especially where luminaires are located close enough to the shelf-lined walls to compensate for the lower illumination values obtained there at normal spacings. This spacing is less critical for indirect lighting than for direct or semi-direct systems. Book shelves located between, or adjacent to, windows open to the sky may need supplementary lighting because of the glare from the sky brightness, even though they may be lighted to the same footcandle value as other shelves.

(c) Supplementary shelf lighting units are often spaced too far apart along the shelves resulting in spotty illumination, or too close to the shelf faces, the upper shelves receiving most of the lighting and the bottom very little. The former condition can be corrected by closer spacing or using continuous angle trough reflectors for filament or fluorescent lamps.

Figure 13. Illustrating stack lighting by means of filament-lamp luminaires with supplementary units for carrel.

(d) The spacings of individual lighting units along the shelf should not exceed 0.80 H (where H is the mounting height of the units above the floor) unless specially designed. If a fairly uniform illumination from top to bottom shelves is wanted, the individual units, or angle troughs, should be located a distance (D) out from the shelf face not less than 0.50 H. Where this is not practical or desirable, the distance out (D) can be reduced to 0.25 H if a narrow beam lighting unit designed for such applications is used. The center of the narrow beam is usually aimed slightly below the center shelves, and the reflector cut-off or distribution must be high enough to illuminate the upper shelves.

(e) Although the average footcandle value and its distribution over the shelf face will depend upon the efficiency and light distribution characteristics of the lighting equipment, it can be estimated that an average of 10 footcandles will be obtained for each 200 lumens per running foot of shelf length supplied.

7.2.2—*Piers*—Book piers, or shelf sections, that protrude into the room add book storage capacity and are also very useful in breaking large reading rooms into smaller and more intimate alcoves. These protruding sections absorb light and thus reduce the utilization of both natural and artificial light. Because of this, supplementary shelf lighting may be needed in such alcove sections. It is possible, however, to so locate and arrange the general lighting system luminaires with respect to the alcoves and shelves that satisfactory reading illumination is obtained, and no additional light will be needed on the shelves.

7.2.3—*Stacks*—**(a)** Those who are searching for books in the book stack area are usually there for a relatively short time. During that time, however, it is necessary to read quickly a great many book titles located on any shelf between the top and bottom. The task is made more difficult by the predominance of dark bindings, their scuffed condition, and half-obliterated titles and classification numbers.

(b) Undoubtedly, the stack areas have the least satisfactory illumination in most libraries. Practically, the problem is to illuminate adequately, from top to bottom and end to end, the walls of a room with dark walls and ceiling, 2½ to 3 feet wide, 15 or more feet long, and 7 feet high. The logical

position of light sources is on the center line of the aisle at the ceiling; however, under these conditions they may be six or more feet from the bottom shelves, with the light striking the book titles at a very oblique angle. Because one must look up to read book titles on the upper shelves, the glare from the light source, which may be only two feet away, should be reduced to the point where it presents no interference with vision. (Daylighting is seldom used in stacks.)

(c) The problem of adequately lighting book stacks is further complicated in some of the new modular libraries by the need for complete flexibility in the location and arrangement of the stack ranges. This means that where the luminaire positions are fixed, the stack faces may fall into any position with relation to the luminaires. The need is for a lighting system which is suitable for any arrangement of stack ranges and adequate also for the purposes of a reading room in the event that such rearrangements are made.

(d) It has been common practice to light stack aisles by low-wattage (25-40 watts) filament lamps, with or without flat shades, spaced six or more feet apart along the aisle. However such lamps are glaring and the illumination on the stack faces is very spotty, varying from 30 footcandles at the top to 0.3 at the bottom; the illumination between lamps drops to an even lower figure. The illumination can be made more uniform by spacing lamps close together, but this increases the glare because of the additional lamps.

(e) The results of tests with many specially designed stack lighting units show that rows of luminaires using filament lamps or continuous rows of fluorescent lamps with concentrating louvered reflectors can provide good uniformity of illumination from the top to the bottom shelf. (See Figs. 10 to 13.)

(f) Lighter-colored ceilings than those now commonly used in stack areas will aid in the utilization of light from any unit; light-colored floors will increase the illumination on the bottom shelf. Tilting the books on the bottom row of some types of stacks will make it possible to obtain more footcandles on the titles and make them easier to read.

7.2.4 *—Carrels* — In some libraries, carrels are placed at the ends of the stack ranges as small enclosures, each with a study shelf and chair, or they may be simply open study tables at the ends of the stacks. See Fig. 13. They occur in other libraries as small reading areas located close to the stacks, or built into the stack rows where browsing among books in the stacks may be convenient. In the case of carrels open at the top, the general illumination of the area containing them should be designed to provide the proper level and quality of illumination for reading. Closed carrels should be treated as small rooms and may be lighted in either of two ways. A system of general illumination may be used which diffuses the whole carrel with light. Localized general lighting is suitable if properly arranged to avoid high brightness ratios and veiling reflections on the printed page.

Figure 14. Bilateral daylighting in children's room, Brooklyn Public Library. Note reading racks at far left and right.

Appendix A

Reading Racks

Any report on conditions which are intended to make reading easier would be incomplete without consideration of the problem of tilting the book at right angles to the reader's normal line of vision.

Few libraries now have any provisions for supporting the book being read in any position other than flat on the table. Books laid flat are in a plane about 45 degrees from the reader's line of sight; the result is that the type is foreshortened and, therefore, has an apparent height less than normal. For example, material printed in 10-point type is seen at its true height when the book is held at right angles to the line of vision; it has an apparent height of only 7-point type when the book is laid flat on the table; type width is not changed, but its visibility, and certainly its readability, has been materially reduced because of the foreshortening of its height. Laboratory tests have shown that more illumination is required to make reading matter laid flat on the table as readable and visible as when it is held normal to the line of vision.

Many readers hold their books at the most advantageous angle, but this is not practical for long reading periods, and certainly not so for the student who must write or take notes as he reads.

Methods for holding the book in the desirable position might be simple movable book racks. Other methods might include adjustable racks built into the reading table or desk tops at each chair position. Whatever the method used, a flat area is needed at either side of the rack for writing purposes on assumption that writers may be either right- or left-handed.

Probably one good reason for reading racks not being more commonly used is the fact that they are not practical for use with reading table lamps. With the trend toward the exclusive use of general illumination, however, we may find the increased use of reading racks, especially for those who must read intensively or for long periods.

Appendix B

Daylighting*

The amount of daylight received in a room interior depends among other fac-

*For further information see I.E.S. Recommended Practice of Daylighting." ILLUMINATING ENGINEERING, February 1950.

tors upon the total area of the windows and their ability to transmit light. Of equal, or greater, importance in getting the light distributed to the side of the room having no windows is the height of the window in relation to the room width, since it is the upper portion of a window that contributes the most light to the opposite side of the room. A ratio of window height to room width of 0.5 is indicated as the lowest ratio providing minimum requirements. Greater ratios will produce not only higher illumination values at the back of the room but also improvement in the uniformity.

No doubt, this need for the greatest possible utilization of natural light was one of several factors which led to the use of high ceilings and windows in most of the libraries designed during the past. Modern techniques in obtaining good air-conditioning and artificial lighting have removed much of the need for high-ceilinged rooms and this, coupled with increased building costs, may lead to generally lower ceilings. Libraries now under construction have ceiling heights in the clear as low as 9 feet 3 inches; the usefulness of daylight in such an interior is limited practically to a band along the fenestrated side equal to about twice the window height if unilaterally daylighted, or about three times the height if lighted from two sides.

In the interest of maintaining comfortable seeing conditions in reading rooms, the type of glass used in windows, the method and degree of shading the windows, and the reflectance values of major room surfaces become important. Polished plate or clear sheet glasses or light directing glass block are employed in windows. The prismatic light-directing glass blocks are designed to redirect a part of the sunlight falling on the blocks outside to the ceiling of the room interior for reflection to the back of the room. Techniques have been developed for using these blocks in combination with clear glass vision strips and Venetian blinds of both fixed and adjustable blade types. When sheet glass or glass block having a lower transmission factor than clear glass is used, the window area must be increased to obtain corresponding illumination levels.

Window shades, baffles, or louvers should be used for the windows in reading rooms, offices, and other areas when the sky brightness or sunlight becomes uncomfortable or glaring to persons reading or working in fixed positions. Horizontal or vertical overhangs outside the windows also help eliminate glare from direct sunlight. It is a good plan to orient, as far as possible, all

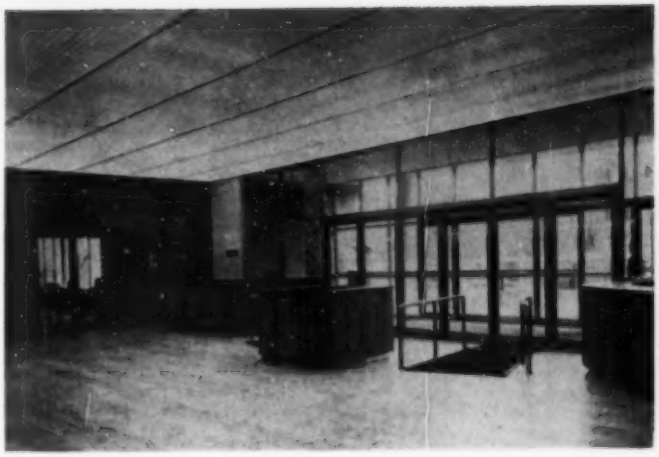


Figure 15. Louverall ceiling, entrance lobby, Lamont Library, Harvard University.

seated room occupants so that bright windows do not fall in their normal field of view, and also so that they do not cast shadows on their reading material or work. (See Fig. 14.)

Walls and ceilings should be finished in light colors having a flat or egg-shell finish. Desk and table tops should have a flat finish and all furniture and floors should have a light color. For recommended reflectance factors see Table II, paragraph 3.2, *Room Finishes*. Periodic cleaning should be arranged to maintain the interior surfaces with high reflectance values and windows with a high transmission factor.

Appendix C

Characteristics of the Five Types of Artificial Lighting Systems

C-1—***Indirect***—The light from indirect luminaires is directed to the ceiling and upper walls which reflect it diffusely to the work plane. Because the useful light comes from a large area, low brightness surface, the shadows from indirect lighting are soft and reflected glare is at a minimum. When indirect lighting is used, it is essential that the ceiling be finished in a light color using non glossy finishes and that it be maintained in good condition.

Indirect reflectors are available in a variety of designs for standard inside-frost or silvered-bowl lamps. Silvered-bowl lamps have the advantage of furnishing a new reflecting surface every time a lamp is changed, resulting in excellent maintenance characteristics. Luminous indirect luminaires are available for fluorescent lamps. Both fluorescent lamps and filament lamps fitted with light control devices are well-suited for cove lighting although the utilization is generally low.

Cove lighting, in combination with suitable room appointments, creates a restful and luxurious atmosphere. It will, accordingly, find suitable applications in assembly rooms, and for special collections and similar applications where appearance is important. It will be suitable, also for the general illumination of areas in which are located self lighted shelves, display cases, etc., or where displays of special interest are spot or floodlighted from supplementary sources.

C-2—***Semi-Indirect***—This system is similar in character to indirect lighting; since, however, more light comes directly from the luminaire, the utilization will be slightly higher than for indirect lighting, and the shadows and reflected glare more discernable. Because of its luminous character, the luminaire itself becomes a factor in the brightness and decorative pattern.

C-3—***General Diffuse***—Luminaires of this group direct about equal amounts of light upward and downward. This group includes opal enclosing globes (filament), and bare fluorescent lamps, all of which have strong components of light in the near horizontal angles; the direct glare that results from this horizontal light makes them generally unsuited for reading rooms, offices, etc. They are suitable for use in hallways and other service areas.

Units of this classification which have most of the light in the horizontal angles shielded out are known as direct indirect. They are available for fluorescent lamps and have about the same fields of application as semi-direct or semi-indirect.

C-4—*Semi-direct*—The desirable characteristics of this system include, (1) the high utilization of light because of its strong downward component, and (2) enough light direct to the ceiling to relieve the darkness of the ceiling encountered with most types of direct lighting. When used to light reading rooms, fluorescent equipment is preferred over filament because of the larger luminous areas, softer shadows, and lower reflected glare. Some fluorescent luminaires of this classification are open-bottom, louvered; others are covered at the bottom with diffusing glass or plastic materials.

C-5—*Direct*—This system has the maximum utilization and the simplest maintenance. Where direct lighting equipment, or downlights, are placed on wide spacings, shadows may be objectionable, illumination non-uniform, and an undesirable brightness ratio obtained between the luminaires and the adjacent ceiling areas. Dark ceilings can be lightened, however, by providing other indirect sources and, to some degree, by the use of light-colored floors, table tops and furniture. Direct lighting becomes more acceptable for library use as the luminous areas of the luminaires become larger and lower in brightness, or where the luminaires are spaced closer, approaching a uniform ceiling. One of the types of direct lighting often employed at check out desks and other places where light is wanted over a restricted area is the filament lamp prismatic plate type installed flush in the ceiling. (See Fig. 2.)

Coffers are one type of direct lighting well suited for general illumination in libraries. These are essentially cavities, finished in a light color, each containing lamps and shielding media. They may be either open or closed. Coffers of various shapes and dimensions become architectural elements that have many possibilities of architectural treatment because of the varieties of brightness patterns that are possible. For example, see Fig. 1.

Two useful clear materials that have in-built or self-contained louver elements are available for covering coffer openings and luminaires. One of these is plastic; the other is glass. Where the material is diffusing, it is likely that the coffer area so covered will be of fairly high brightness. Since there will be no light from the flush coffers to light adjacent ceiling areas, the high contrast in brightnesses may be uncomfortable. Indirect illumination from other sources can be used to reduce this contrast, and the light reflected by light table tops, floors and lower sidewalls will be helpful. The collection of dirt on all flat transmitting surfaces will cause a more rapid depreciation of the light output than open-bottom coffers and, accordingly, more maintenance will be needed.

Another form of direct lighting is known as the louverall system. This system employs a wall-to-wall system of multi-cell louvers above which are located fluorescent or silvered-bowl filament lamps on spacings which make the vertical louver blades reasonably uniform in brightness. The lamps can be equipped with trough reflectors or, more simply, located in a shallow cavity which, for best efficiency, should be painted or finished in a light color. (See Fig. 15.) Maintenance of louvered systems is good because dirt falls through the louver openings and has little tendency to collect on the vertical surfaces of the louver blades. For offices and reading rooms, the louvers should be designed to shield all lamps from view within an angle of 45 degrees above the horizontal.

Luminous ceilings (sometimes called "artificial skylights") are composed of direct luminaires covered by glass or plastic diffusing panels, either in sheet or woven cloth form. Such an installation reduces the brightness of the lamps and thereby reduces the reflected glare or veiling reflections in glossy reading material.

COMPLETE EXPENSE ANALYSIS

General Information	Lighting Method #1	Lighting Method #2
Installation Data		
Type of Installation		
No. of Rows		
Luminaires per row		
Lamps per luminaire		
No. of lamps		
Watts per lamp (incl. accessories)		
Total Watts		
Maintained Footcandles		
Calculation of Complete Expense		
Capital Expense		
No. of Luminaires		
Estimated cost each installed		
Total cost luminaires		
Estimated wiring per luminaire		
Total cost wiring		
Total (luminaires plus wiring)		
Assumed years life		
Total Capital Expense per Year		
Energy Expense		
Total Watts		
Average Hours Used per Year		
Kilowatt hours per year		
Average Rate per Kilowatt hour		
Total Energy Expense per Year		
Lamp Renewal Expense		
No. of lamps		
Avg. hours used per year		
Total lamp hours per year		
Rated lamp life in hours		
Avg. lamp renewals per year		
Net price each		
Replacement expense each (labor)		
Net price plus repl. expense each		
Total Lamp Renewal Expense per Year		
Cleaning Expense		
No. of washings per year		
Man-hours each (est.)		
Man-hours for washing		
No. of dustings per year		
Man-hours each (est.)		
Man-hours for dusting		
Total man-hours		
Expense per man-hour		
Total Cleaning Expense per Year		
Repair Expense		
Repairs (Based on Experience, allocation of repair man's time, etc.)		
Est. Total Repair Expense per Year		
Recapitulation		
Total Capital Expense per Year		
Total Energy Expense per Year		
Total Lamp Renewal Expense per Year		
Total Cleaning Expense per Year		
Est. Total Repair Expense per Year		
Complete Lighting Expense for Year		
Complete Lighting Expense per Footcandle per Year		

Appendix D

Comparsion of Filament and Flourescent Light Sources

D-1—*Economics*—The initial investment in a fluorescent lighting system is usually higher than for an equivalent filament system; the lighting equipments are larger and more of them are needed. Since fluorescent lamps have a longer life lamp replacements are less frequent, but the fluorescent system will require

more time and effort for cleaning and maintenance than an equivalent incandescent system. Fluorescent luminaires are available in a wide variety of types and construction; in some, the construction is simple with easy access to the lamps; others are less simple. The lamp replacement and cleaning problems should be considered and luminaires selected which are easy to relamp and clean. Artificial skylights or louverall systems built into high ceilings should be accessible from an attic space above, or provision made for portable extension ladder maintenance devices to be operated from the floor.

The overall cost of lighting should be calculated for each lighting system because of wide variations in both the owning and operating costs. In some buildings the present wiring system may be adequate; in others, a complete rewiring is necessary. Some institutions include amortization figures; others do not. When figuring the cost of lighting equipment, it will be found that there is a wide range both within the fluorescent field, and also for filament equipment as compared with fluorescent. Variations occur, also, in the cost of electrical energy.

Complete cost figures for lighting (see Complete Expense Analysis, page 196) will include the following:

Owning Cost — Cost of luminaires plus hanging. Cost of wiring, if necessary, which includes the required number of ceiling outlets, switching controls, and branch-circuit wiring to the sub-panel board. Added to this may be the amortization which includes interest, insurance, etc.

Annual Operating Cost — This includes the cost of electrical energy based upon the annual hours of operation. To this must be added the cost of lamps for renewals, and a figure for the cost of cleaning the equipment.

So far in this report the two illuminants have been considered as being used separately; there is no inconsistency, however, in combinations of the two. Fluorescent lamps have the advantages of high efficiency in the production of light, low production of heat, and adaptability to modern architectural design; filament lamps, on the other hand, are simple and compact and, because the light sources are relatively small, a wide range of controlled light patterns are possible, varying from the broad distribution of the silvered-bowl lamps in indirect luminaires to spot or flood beams for downlighting.

D-2—*Color Temperature*—The color temperatures of filament lamps commonly used are within the range of 2800-3000K. Fluorescent lamps of about this same range are available; such lamps could be used in combination with filament lamps with little obvious variation in appearance. Fluorescent lamps of 3500K are widely used, and those of 4500K find extensive acceptance. The 4500K lamp has a cooler appearance than the 3500K lamp and looks white without appearing cold; the 4500K lamp, particularly, mixes well with natural daylight, and both are successfully used in combination with filament lamps. Daylight fluorescent lamps are preferred by some where artificial and natural daylight are mixed, but when used alone, the room appearance—at least under low footcandle levels—may be considered cold. At higher levels of 30 or more footcandles, the cold appearance is less obvious.

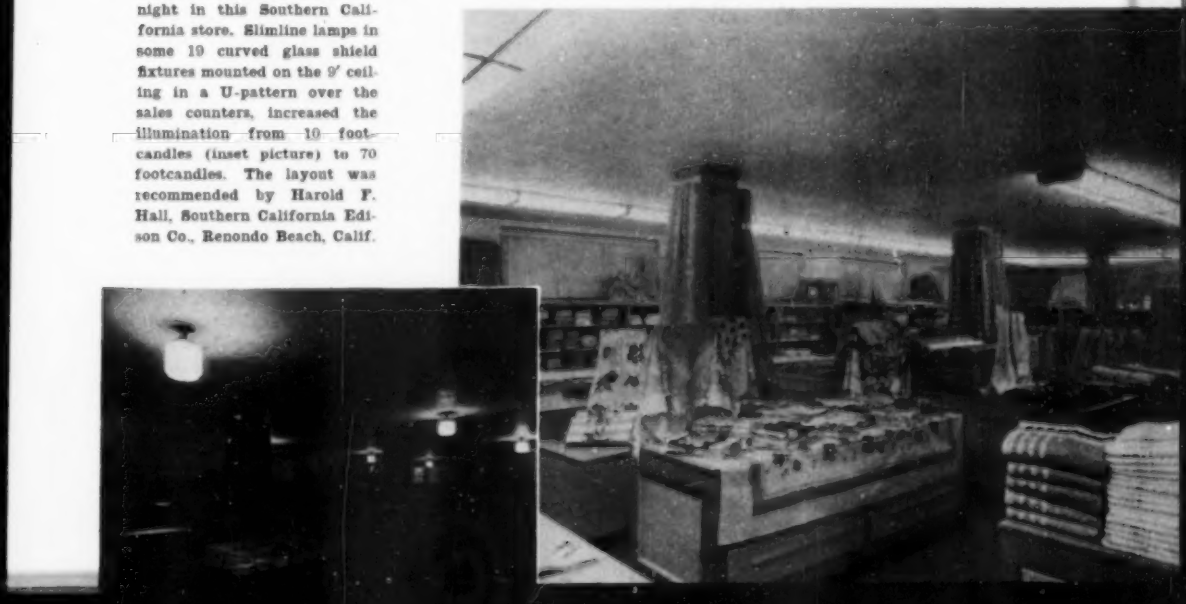
D-3—*Relation to Air Conditioning*—From the standpoint of air conditioning, the total heat load generated by the lighting system is in direct proportion to the total electrical load (watts) in the room. For filament lamps, the load is the total lamp watts; for fluorescent, it is the total lamp watts plus the ballast watts. Because fluorescent lamps are roughly 2½ times as efficient as filament lamps, the total watts required by fluorescent lamps to produce a given footcandle value is half or less that required for filament lamps. Thus fluorescent lamps will add half or less as much to the air temperature (or load on air-conditioning system) per footcandle as will filament lamps.

Recommended Practice of Library Lighting

This report, the Society's first official study on lighting for seeing tasks in libraries, is available in booklet form with standard blue cover at 50 cents each to 4 copies; next 20, 25 cents each; all over 24, 15 cents each. Publications Office, Illuminating Engineering Society, 51 Madison Ave., New York 10, N. Y.

Myers Department Store
Whittier, California

Seven times more light and untold increases in customer attraction were achieved over night in this Southern California store. Slimline lamps in some 19 curved glass shield fixtures mounted on the 9′ ceiling in a U-pattern over the sales counters, increased the illumination from 10 footcandles (inset picture) to 70 footcandles. The layout was recommended by Harold F. Hall, Southern California Edison Co., Redondo Beach, Calif.



TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Summary of Council Action at Its February Meeting, New York

The third meeting of the 1949-1950 Council was held February 8 at the Hotel Roosevelt, New York, with President C. H. Goddard, presiding. In addition to Mr. Goddard, those present included: R. W. Staud and R. R. Brady proxy for Lee E. Tayler, Past-Presidents; S. G. Hibben, Walter Sturrock, Vice-Presidents; E. M. Strong, Treasurer, A. H. Manwaring, General Secretary; R. L. Biesele, Jr., Myrtle Fahsbender, Duncan M. Jones, J. E. Mueller, Hoyt P. Steele, M. N. Waterman, Directors; Joe B. Browder, G. F. Dean, W. F. Little proxy for F. A. Covington, G. K. Hardacre, proxy for J. S. Schuchert, S. B. Williams proxy for T. H. Shepherd, Regional Vice-Presidents; G. Ross Henninger, Editor-in-Chief, I.E.S. Publications; Ruby Redford, Production Editor; Eve Freyer, Assistant to Technical Director. Also present were C. L. Amick, R. F. Hartenstein, Caroline Horn, E. C. Huerkamp, L. B. Moore, and John Ronayne.

Membership Totals

The influx of new members into the Society continued the upward trend of the membership. The report to Council by the Board of Examiners of the election of 80 Associates, and action of Council on the election of 15 Members, together with other changes, resulted in membership totals as shown in the following tabulation:

September 30, 1949		February 8, 1950
6883	Total Membership	7109
26	Members Emeritus	28*
44	Fellows	43
1521	Members	1571
5046	Associate Members	5173
246	Student Members	294

*Includes 6 Fellows of the Society

Two New Committees

Favorable letter ballot of Council has established two new technical committees of I.E.S. A Committee on Protective Lighting will undertake studies to prepare standards for protective lighting of plants, yards, boundary fences, adjoining highways, railroad sidings, and waterway approaches for the purpose of reducing fire and theft risks, and making policing more effective. Chairman of this new committee will be J. W. Lee; also serving are J. C. Forbes, H. E. Mahan, Gene Rae, and Dana W. Rowten.

A Committee on Television Lighting also appointed will study and report on the lighting for (a) production of television programs and (b) for optical reception of television programs. Chairman of this committee will be H. A. Kliegl, with the following also serving: Robert Bannon, F. E. Carlson, D. P. Caverly, E. W. Commery, R. M. Gurin, H. Kozanowski, R. C. Lanciano, R. S. O'Brien, Gertrude Rand, Lionel Rodgers, Ernst Wolf, Fred Wolfe, R. L. Zahour.

Sustaining Members

Three new Sustaining Members were elected, on recommendation of G. J. Taylor, Chairman of the Sustaining Membership Committee. Members elected were:

Warren Electric Company
P. O. Box 2594
Houston, Texas
Official Representative—J. R. Thompson

Frank C. Teal Company
3222-24 E. Jefferson
Detroit 7, Michigan
Official Representative—Harold C. Smith

Unistrut Corporation
4118 Monroe Ave.
Wayne, Michigan
Official Representative—James W. Attwood

Local Representatives Appointed

Recommendations from the Pacific Northwest Region were presented by S. G. Hibben, Chairman of the Local Activities Committee, covering the appointment of eight additional Local Representatives in this Region.

Mr. Hibben also reported that steps are being taken to further the local activities by appointment in the near future of local representatives in Honolulu, Hawaii, and Mexico City, Mexico.

Public Relations Activities

The Committee on Public Relations and Information presented a report to Council on their activities and recommendations, through John Ronayne, a member of the committee.

The committee noted that each of the sections and chapters has been encouraged to appoint a local Public Relations Chairman and that a letter is being prepared stressing the importance of this assignment. They also reported that a Guide for public relations in local communities is now under way for circulation to the local groups.

The committee is also preparing a series of pages for publication in ILLUMINATING ENGINEERING describing to

Regional Conferences

March 6-7, 1950	Southern Region	Atlanta, Ga. Hotel Henry Grady
March 23-25, 1950	Pacific Northwest Region	Seattle, Wash. Edmond Meany Hotel
May 11-12, 1950	Canadian Region	Montreal, Canada Mt. Royal Hotel
May 17-19, 1950	Midwestern Region	Milwaukee, Wis.
May 18-19, 1950	East Central Region	Philadelphia, Pa. Warwick Hotel
May 22-23, 1950	Great Lakes Region	Buffalo, N. Y.

the membership the various aspects of the Society's program.

Society Display at E.E.I.

On recommendation of the Public Relations Committee, Council approved participation by the Society in maintaining a display area at the Edison Electric Institute Conference in Chicago, April 3 to 6. An illuminated I.E.S. shield and a display of the Society's publications is contemplated.

Regional Boundaries Under Study

S. G. Hibben, Vice-President, showed a large map outlining the present I.E.S. Regional boundaries and recommended certain boundary changes which would create two new Regions. He indicated that this problem will be a major discussion at the forthcoming Local Activities Conference, tentatively scheduled for June in New York.

Lighting Design Practice Approved

A report on "Uniform Methods of Presentation and Calculations of Room Indexes, Coefficients of Utilization, and Maintenance Factors" presented by C. L. Amick, Chairman of the Committee on Lighting Design Practice, was approved by Council, and referred to the Publications Committee for action as to its publication and distribution.

Task Committee Reports Dues Increase Study

E. M. Strong, Chairman of the Task Committee appointed last year to study the possible needs and other factors involved in last year's recommendation of a dues increase, reported in detail a thorough study of the subject undertaken by his Task Committee. Based on the committee's study, he submitted their recommendation for an increase next year of $2.00 in Associate and Member dues. Considerable discussion followed the formal motion for such action. A final show of hands favored placing the recommendation before the membership for vote on the April ballot, with suitable explanation as to the need.

Further discussion initiated a motion to authorize a study of a long-range program for the Society, and of the areas in which it will operate.

W. F. Little to Receive 1950 I.E.S. Gold Medal

By unanimous action of Council at its February meeting, William F. Little, of Electrical Testing Laboratories Inc., has been awarded the 1950 I.E.S. Gold Medal. Highest honor in the field of illumination, the Gold Medal is awarded "for meritorious achievement conspicuously furthering the profession, art, or knowledge of illuminating engineering." Presentation of the Medal and the Award Certificate will be made to Mr. Little at the National Technical Conference next August.

Of the many important accomplishments in illuminating engineering leading to Mr. Little's election to the award, perhaps best known is his original work in photometry during the early development of that science. His work in this field has contributed basic knowledge toward the development of standard specifications for numerous phases of lighting, including illumination standards for motor vehicle lighting, industrial, commercial, motion picture, and natural lighting, among others.

W. F. Little
1950 Medallist

In addition to his valuable contributions to the art and science of illuminating engineering, no little of Mr. Little's efforts have been devoted to the objectives of the Illuminating Engineering Society, in its administrative affairs as well as its technical progress. He served as President of the Society in 1930-1931, and over a period of some 25 years has been active, as Chairman or member on numerous technical committees.

Some recognition of his valuable contributions came in 1944 with the establishment by the Society of the Fellow Grade. Mr. Little was among the first ten Members so honored, and was the first Chairman of the Board of Fellows.

For many years Mr. Little has been Engineer in Charge of Photometry at the Electrical Testing Laboratories, Inc. In this capacity he has dealt with photometric problems on all phases of lighting equipments, and has served as consultant on photometry for large scale visibility research.

In addition to his valuable work with the Illuminating Engineering Society, Mr. Little is a member also of the Society of Motion Picture Engineers, Optical Society of America, Inter-Society Color Council and the Society of Automotive Engineers.

Titus G. LeClair To Head AIEE

To succeed its current president—James F. Fairman, Vice-President of the Consolidated Edison Company of New York—the American Institute of Electrical Engineers has announced the nomination of Titus G. LeClair, Assistant Chief Engineer, Commonwealth Edison Company, Chicago, Ill. Subject only to a routine election, Mr. LeClair will take office the first of August. The announcement, made by A.I.E.E. during its recent Winter General Meeting in New York January 30-February 3 included the following additional nominations for the administrative year 1950-51:

Vice Presidents: J. G. Tarboux, Prof. & Assistant Director, School of Electrical Engineering, Cornell University, Ithaca, N. Y.; C. S. Purnell, General Industry Supervisor, Industrial Sales Department, Westinghouse Electric Corporation, New York, N. Y.; J. R. North, Chief Electrical Engineer, Commonwealth Services, Inc., Jackson, Mich.; H. B. Fritz, Chief Engineer, Southwestern Bell Telephone Company, St. Louis, Mo.; J. A. McDonald, Superintendent, Service Shop, General Electric Co., Salt Lake City, Utah.

Directors: W. J. Barrett, Electrical Coordination Engineer, New Jersey Bell Telephone Company, Newark, N. J.; A. G. Dewars, Manager, System Planning, Operating Department, Northern States Power Company, Minneapolis, Minn.; Victor Siegfried, Chief Research Engineer, American Steel and Wire Company, Worcester, Mass.

The program for the AIEE Winter General Meeting set a new record, with 227 papers presented at 53 technical sessions and 19 technical conferences.

The reported attendance of 3100 also sets a new record.

The opening general session of the meeting featured an address by President Harold E. Stassen of the University of Pennsylvania; also, an unique feature in the form of a speech delivered by Sir Ernest Benn, recorded in London for the occasion and flown to New York for presentation over the public address system. Mr. Stassen called for more constructive individual initiative to preserve the traditional American way of life. Sir Ernest, reputed to be the largest European publisher of scientific books, pointedly discussed the topic "Why Go the Way of Britain?" in the direction of statism and resulting loss of individual freedom.

The AIEE presented to Dr. Vannevar Bush, renowned scientist and organizer of war-time scientific research and development and presently President of Carnegie Institution of Washington, its top recognition award of honorary life membership, putting Dr. Bush into the category of Lord Kelvin, Guglielmo Marconi, Michael Pupin, Thomas A. Edison, Elihu Thomson and Frank B. Jewett. The AIEE Hoover Medal was presented posthumously to Dr. Frank B. Jewett, and its Edison Medal was presented to Dr. Karl B. McEachron of the General Electric Company, Pittsfield, Mass.

Western Michigan Chapter Holds Charter Meeting in Grand Rapids

The brand new I.E.S. Chapter in Grand Rapids, Michigan, became officially the Western Michigan Chapter February 2, with the presentation to its Chairman of the Chapter Charter. Also presented was a special gavel as gift to the new Chapter from the Winnipeg (Canada) Chapter, next "youngest" in the I.E.S. group. Walter Sturrock, National I.E.S. Vice-President was guest of honor, and made the presentation to Chairman Harold P. Earley, Consumers Power Co., Grand Rapids.

Nearly 100 members and guests, including the officers and Board of Managers of the Michigan (parent) Section, attended the meeting, held as a dinner meeting at the beautiful Cascade Hill Country Club. Presiding at the presentation ceremonies was W. A. Stannard, Midwestern Regional Vice-President, who spoke on the growth and history of the new Chapter. Mr. Sturrock, who was substituting for President Goddard, also addressed the group on the aims and objectives of the Society, and accepted for himself and for President Goddard, wooden shoes as mementoes of the occasion.

While the first regular meeting of the new Chapter was announced by Chairman Earley as scheduled for March, actually numerous outstanding meetings have been held monthly by the Grand Rapids group for some time.

WESTERN MICHIGAN Chapter receives official Charter at ceremonial dinner meeting February 2, at the Cascade Hill Country Club, Grand Rapids, Michigan. Left to right, Walter Sturrock, National Vice-President, who made the presentation; A. P. Hammerstrom, Chairman of the Michigan Section, "parent" of the new Chapter; W. A. Stannard, Regional Vice-President, and Harold P. Earley, Chairman of the new I.E.S. Chapter.

Transactions for Sale

A complete set of Transactions of I.E.S., in excellent condition, for the years 1930 through 1939, is available for sale on a bid basis. Anyone interested in obtaining these volumes may write to Mr. R. A. Crosby, 725 West 109 Place, Los Angeles 44, California.

Canadian Magazine Features Flour and Feed Mill Lighting

The February number of the Canadian publication *Canadian Milling and Feed* was a special issue featuring lighting in the milling industry. Foremost editorial contribution to the issue was the six-page I.E.S. technical committee report "Lighting for Flour Mills" reprinted from the November issue of ILLUMINATING ENGINEERING, through special arrangements with I.E.S.

Twin City Section Sponsors Architectural Contest

The Twin City Section of I.E.S. recently completed a prize contest for the students in the School of Architecture at the University of Minnesota.

The problem was the design of a meeting room in a town hall. The students were to incorporate in this interior a well-designed, well balanced and versatile scheme of lighting. The challenge in the design came not in making an elaborate interior, but designing it in keeping with the activities of a small town.

The program was given in conjunc-

tion with a course in lighting and wiring which was conducted over a five-week period prior to the contest. In addition, two members of the Twin City Section were invited to the school to give criticisms to the students before the problem was submitted. Three members of the Section sat in on the judging and offered suggestions as to the merits of the various problems.

Prizes were cash, plus Student Membership in the Illuminating Engineering Society. From forty entries, the following were judged winning installations:

John G. Rauma — First Prize — $45.00 and Student Membership.
Loren A. Duerr — Second Prize — $20.00 and Student Membership.
Lewis G. Abels — Third Prize — $20.00 and Student Membership.
Robert T. Jackels — Student Membership.
Robert I. Dunn — Student Membership.
James B. Horne — Student Membership.
Richard J. Rafferty — Student Membership.

The winning students and the School of Architecture faculty were guests of the Twin City Section at a dinner following the contest, during which the presentations were made.

ARCHITECTURAL Students at the University of Minnesota compete for cash prizes and Student Membership in I.E.S. in lighting competition sponsored by the Twin City Section. Winners, from 40 entries are shown: Left to right — Robert T. Jackels; Lewis G. Abels (Third Prize); James B. Horne; Loren A. Duerr (Second Prize); Richard J. Rafferty; Robert I. Dunn; Walter K. Vivrett; and John G. Rauma (First Prize).

New Orleans Section Offers Lighting Course

Starting March 1 through April 27, the New Orleans Section is conducting a lighting study group weekly at the New Orleans Public Service Auditorium. A well balanced lighting fundamentals program includes:

Principles of Light—by Hutson Colcock, Sales Engineer for Curtis Lighting and Wheeler Reflector Co.
Light Sources—by Joseph J. Sanders, Westinghouse Electric Corp.
Illuminating Design—by Mario G. Zervigon, Consulting Engineer.
General Electric Lighting Clinic — Open to public.
Industrial Lighting—by C. D. Paine, Westinghouse Electric Corp.
Office and School Lighting — by Harbert S. Gregory, Edwin F. Guth Co.
Store Lighting—by Edward D. Meacham, General Electric Supply Corp.
Exterior Lighting and Residential Lighting—Instructors to be announced later.

Institute of Visual Sciences Established at Pacific University

An Institute of Visual Sciences, with the College of Optometry as nucleus, is in the making at Pacific University, Forest Grove, Oregon. The Institute of Visual Sciences, a university announcement said, is part of administration plans to keep Pacific University in step with the rapidly growing industrial and cultural development of the Pacific Northwest.

Significant steps have already been taken. Courses in illumination and color, occupational vision, eye protection devices, optics and bio-physical research have already been arranged for the 1950-1951 academic year, or are in preparation. These are in addition to the standard optometric courses.

First goals for the Institute of Visual Sciences are, new curricula leading to a degree in optics and to a professional degree in illuminating engineering.

Plans are to make the Institute a unit of the university in which students will find courses in study covering all the physical, psychological and physiological factors of light and sight. Services of the Institute will be made available to education and industry.

Home Lighting Data Sheet Packet Available

A packet of 23 I.E.S. Home Lighting Data Sheets is currently being selected by the Sub-Committee of Home Lighting Data Sheets, for distribution to lighting personnel interested primarily in residential lighting. Price of the selected packet of data sheets will be $1.25, the same as for the regular series subscriptions.

Home Lighting Data Sheets are included with the regularly published series of I.E.S. Data Sheets. It has been found, however, that residential lighting personnel would find it useful to be able to purchase these particular sheets as a separate packet. The 23 sheets selected by the Sub-Committee, under the Chairmanship of Mary Tsepke, Detroit Edison Co., include sheets published during the past several years and considered by the committee to be in accordance with modern lighting practice for the applications involved.

Requests for the separate packet of Home Lighting Data Sheets will be received at I.E.S. Headquarters, Publications Office.

Combined Contractor-I.E.S. Meeting Draws Large Attendance

Nearly 100 electrical contractors and lighting industry men attended a meeting sponsored jointly by the Independent Electrical Contractors Association of Philadelphia, and the Philadelphia Section of I.E.S. recently. Most of the members and guests also attended

LIGHTING CALENDAR

Society Events

March 6-7, 1950 — Southern Regional Conference, Atlanta, Ga., Hotel Grady.

March 23-25, 1950 — Pacific Northwest Regional Conference, Edmond Meany Hotel, Seattle, Wash.

April 6, 1950 — Meeting of I.E.S. Council, Edgewater Beach Hotel, Chicago, Ill.

May 11-12, 1950 — Canadian Regional Conference, Mt. Royal Hotel, Montreal, Que., Canada.

May 17-19, 1950 — Midwestern Regional Conference, Milwaukee, Wisconsin.

May 18-19, 1950 — East Central Regional Conference, Warwick Hotel, Philadelphia, Pa.

May 22-23, 1950—Great Lakes Regional Conference, Buffalo, N. Y.

June 7, 1950 — Meeting of I.E.S. National Council, New York, N. Y.

August 21-25, 1950 — Southern California National Technical Conference, Hotel Huntington, Pasadena, Calif.

Industry Events

March 3, 1950 — Association of Electrical Construction Engineers, Annual Meeting, 2 Park Ave., New York, N. Y.

March 7-10, 1950 — Essex Electrical League, 6th Annual Electrical Industrial Exposition, Newark, N. J.

March 8, 1950 — Annual Meeting, Inter-Society Color Council, Hotel Statler, New York.

March 13-16, 1950 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

March 20-31, 1950—Greater New York Safety Council, 30th Annual Safety Convention and Exposition, Hotels Statler and Governor Clinton, New York, N. Y.

April 4-6, 1950 — Edison Electrical Institute, 16th Annual Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

April 5, 6, 7, 1950 — 12th Annual Midwest Power Conference, Sherman Hotel, Chicago, Ill.

April 17-18, 1950—Annual Conference, Canadian Electrical Distributors Association, General Brock Hotel, Niagara Falls, Ont.

April 19-22, 1950 — The Electrochemical Society, Ninety-seventh Convention, Statler Hotel, Cleveland, Ohio.

May 15-18, 1950 — National Fire Protection Association, 54th Annual Meeting, Haddon Hall, Atlantic City, N. J.

June 5-7, 1950 — Edison Electrical Institute, 18th Annual Convention, Atlantic City, N. J.

June 13-16, 1950 — American Institute of Electrical Engineers, Summer General Meeting, Pasadena, Calif.

June 13-16, 1950 — National Association of Electrical Distributors, Atlantic City, N. J.

June 18-19, 1950 — 60th Annual Meeting, Canadian Electrical Association, Murray Bay, Que., Canada.

June 26-30, 1950—American Society for Testing Materials, 53rd Annual Meeting and 9th Exhibit of Testing Apparatus and Equipment, Atlantic City, N. J.

August 7-19, 1950 — First United States International Trade Fair, Chicago, Ill.

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the get-together dinner which preceded the main meeting.

Two talks were presented at the meeting, each providing factual data of value to contractors and lighting men. Howard L. Miller, former chairman of the Contractors Division of the Electrical Association, discussed "Lumens for Contractors." He emphasized the importance of how closely manufacturers, jobber, contractor, and the utility are interlocked in the electrical industry progress.

George J. Taylor, Day-Brite Lighting Inc., gave a non-technical talk "Dollars for Contractors" and outlined the progress of lamps, fixtures, growth of business, in comparison with early days of the lighting industry.

Pittsburgh Section Sponsors Advanced Lighting Course

In cooperation with the Electric League of Western Pennsylvania, the Pittsburgh Section in sponsoring an advanced source in illumination, February 20 through March 27. Classes are held weekly at the League's headquarters, 600 Grant Street, Pittsburgh, Pa.

Specific lighting applications are the features of this course. "How to" light school classrooms, football fields; how to plan coves and decorative treatment for interiors; how to make a lighting installation analysis; and a review of fluorescent lamp applications, are being studied.

Office Lighting Clinic At Minneapolis

Over a hundred guests, including architects, engineers and office managers, attended the recent office lighting clinic sponsored by the Northern States Power Company of Minneapolis.

Four principal papers were presented:

"Basic Considerations in Planning a Lighting Installation," by L. B. Faist. Discussion led by William Frederick, General Electric Co., Cleveland, Ohio.

"Light Sources and Equipment," by A. B. Hallaway. Discussion led by P. T. Owens, Sylvania Electric Products Inc.

"Economics of Office Lighting," by L. E. Johnson. Discussion by F. T. Tillemans, Westinghouse Electric Corp.

"Analysis of Lighting Systems," by C. L. Seaquist. Discussion led by James Lang, Consulting Engineer.

The meeting concluded with a tour of the 12-story building which has been almost completely relighted since the war.

The Northern States Power Company has an active lighting program under way in the Minneapolis area, and is at present in the process of remodeling their lighting demonstration room to provide demonstrations of basic lighting fundamentals for school children and adult groups.

I.E.S. Student Branch Sponsors Display

The Student Branch of I.E.S. at the University of Illinois is participating prominently in the Illinois Student Engineering Exhibit, one of the year's big features at the University. The Engineering Exhibit is scheduled for March 10 and 11.

The I.E.S. Student Branch will sponsor the Electrical Engineering Department's display of lamps over the past half century, color-quality displays of fluorescent lamps, black light, the use of polaroid in glare elimination, demonstrations of stroboscopic effects, a display of optical illusion produced by light and shadow, and other things pertaining to the field of illumination.

Hundreds of students from high schools and colleges throughout the state are expected to attend the two-day event, designed primarily as an educational meeting to show the layman the organization of different branches of engineering.

IT SEEMS TO ME

Lighting Education

To the Editor:

Mr. Corak's discussion (January issue page 75) concerning the desirability and real need for a suitable graduate program in the field of illumination is gratifying. Nevertheless, the initiation of such program will come about only through the action of

professional organizations such as our own I.E.S.

Connected with the field of optometry, I can readily visualize the needs of an illuminating engineer in our present society where light, vision and the eye receive constantly more and more attention. Where the medical practitioner leaves off and the optometrists take over and likewise where the optometrists leave off and the illuminating engineer takes over are not sharp lines of demarcation. A common basis of knowledge and cooperation would soon emerge if the three professional men would concentrate their know-how into a post-graduate program in illumination.

With the cooperation of the I.E.S., the Optical Society of America and various medical and optometric organizations one year programs leading to a Master's degree in illumination could readily be established in at least three major universities. If the schools selected were located in the East, Mid-West and Pacific slope, a fair distribution of qualified men would aid us in the more and more complex problems of vision and illumination.

It must be realized at the outset that any such program could not be independent on these three forenamed professional practitioners. Illumination does not end at Electrical Engineering or any other physical attitude but does encompass physiology and psychology. And because of this an illuminating engineer must be briefed well on understanding the effects of radiation and its implications upon the human body and mind. Color, as an example, cannot possibly be comprehended as a physical entity since it is physio-psychological.

Attention to this matter (vital, to say the least) of education of the illuminating engineer should receive the prompt action of our various scientific organizations. The initiate of the development of ideas on this line should commence with the Illuminating Engineering Society.—GEORGE P. ELMSTROM, *Los Angeles College of Optometry.*

Classroom Lighting Technique

To the Editor:

In the December 1949 ILLUMINATING ENGINEERING, and in previous publications, attempts have been made to develop a classroom lighting technique that will approach the brightness limits as set forth in the American Standard Practice for School Lighting. The articles and photographs are proof of what has been done and the analysis indicates the resultant effects.

This material is "live ammunition" that a lighting field man uses to present to school boards and educators in aiding them in their classroom lighting problems. However, should a school board member page through the December issue, it may become a little embarrassing for a lighting field man to explain what the visual environment and brightness ratios might be in the Oregon school employing recessed lighting equipment as shown in the advertisement on page 7A.

The article "Application of Recommended Brightness Limitations to School Rooms" together with the mentioned advertisement in the same publication, may not only confuse a school board but it also means the lighting engineer must check the entire journal before displaying it to his potential customer.

It seems to me that the advertisements should be carefully checked before accepting them for publication in order that they do not conflict with the high standards of the Illuminating Engineering Society.—M. H. BRUESEWITZ, *Wisconsin Electric Power Company, Milwaukee, Wisconsin.*

Trotter-Paterson Memorial Lecture Fund Established by British I.E.S.

The Council of the British Illuminating Engineering Society (London) is collecting a sum of money with which to found a public lecture in memory of Mr. A. P. Trotter and Sir Clifford Paterson, eminent British scientists in the field of illumination. The Trotter-Paterson Memorial Lectures will be open to the public without charge and will be widely advertised. The lectures will in general be published in the Society's Transactions.

Cost of the meetings and of publication of the lectures will be borne by the British I.E.S. from its general income; the entire income from the Memorial Lecture Fund will be devoted to the provision of fees for the lecturers.

It will be remembered here in America that Sir Clifford Paterson's work in illumination won him the I.E.S. Gold Medal (in 1948), this Society's highest honor.

Contributions to the Memorial Lecture Fund are being received by the Honorary Treasurer, Illuminating Engineering Society, 32 Victoria Street, London S.W.1, England.

QUEBEC CHAPTER, only bi-lingual group in I.E.S. draws large attendance at open forum on cold cathode lighting and its applications, held at the Laval University, Quebec City. Speaker was Chal Carrothers of Sylvania Electric Products Inc., Salem, Mass.

ABOUT PEOPLE

The election of **Lester T. Avery**, president of the Avery Engineering Co. of Cleveland, as the 1950 president of the American Society of Heating and Ventilating Engineers, was announced at that Society's 56th annual meeting in Dallas recently.

Appointment of **Edward V. Bergui** as manager of the Greater New York Lamp Sales Division of Westinghouse has been announced. In his newly-created post, Mr. Bergui will direct the company's lamp sales in Manhattan, Bronx, Kings and Queens boroughs, and several outlying counties. His headquarters are at 40 Wall St.

Charles I. Brady, formerly Supervisor of Commercial Engineering for the lamp division of Sylvania Electric, has been appointed Division Sales Manager of Lighting Products for the South Pacific Division, with headquarters in Los Angeles.

Burt S. Burke has been appointed manager of the Lighting Division of the Westinghouse Electric Corp., at Cleveland, Ohio. Formerly manager of the company's switchgear distribution apparatus department at East Pittsburgh, Pa., Mr. Burke has been with Westinghouse for 27 years.

F. H. Clark has been named sales manager for the Standard Control Division of the Westinghouse Electric Corp., at Beaver, Pa.

Three new sales divisions of the Middle Atlantic District of the Westinghouse Lamp Division have been formed, according to a recent announcement. **Harry A. Croasdale** has been appointed manager of the Penn-Jersey Lamp Sales Division. **Edward S. Barrington** has been named manager of the Chesapeake Lamp Sales Division with headquarters in Baltimore, Maryland. The Virginia Lamp Sales Division, with headquarters in Richmond, will be headed by **John C. Downing.**

Ray C. Daugherty has been named manager of the Pennsylvania-Ohio Lamp Sales Division, one of three new sales units within the Central District of the Westinghouse Lamp Division. **Harry A. McKinley** has been named manager of the new Michigan Lamp Sales Division, and **Howard J. Thomas** was appointed manager of the Ohio Valley Lamp Sales Division, also within the Central District.

S. F. Davies, Jr., has been appointed manager of the commercial, industrial and floodlighting section of the Lighting Division of the Westinghouse Electric Corp. at Cleveland, Ohio.

James F. Davis has been named District Sales Manager of the New Jersey area for Sylvania Electric Products Inc., it was announced recently. With Sylvania since 1940, Mr. Davis was formerly a territorial salesman with the New York City lighting division.

Robert C. Harper, formerly a member of the Los Angeles Sales Office of Sylvania Electric Products Inc., has been appointed Division Sales Manager of Lighting Products for the Central Pacific Division, with headquarters in San Francisco.

Harold W. Larson, Chairman of the Cornhusker Chapter of I.E.S., has been appointed manager of a newly-created Omaha Lamp Sales Division of the Westinghouse Electric Corp., Omaha, Nebraska. Since 1945 Mr. Larson has been Omaha lamp sales representative for the company.

Creation of a new Texas Sales Division of Westinghouse Electric Corp., has been announced. **Raymond K. Leonard**, formerly of St. Louis, was named manager of the new unit, with headquarters in Dallas, Texas.

Harold H. Maass has been appointed Sales Engineer for Sola Electric Company. He covers the New York metropolitan areas, especially in connection with lighting equipment sales, with headquarters in New York City.

Dr. Joseph Slepian, associate director of the Research Laboratories of the Westinghouse Electric Corp., has been awarded the honorary degree of Doctor of Science by the University of Leeds, London, England. This award marks the second time that Dr. Slepian has been honored abroad. In 1939 he was made "Officier de l'Academie" in France.

Jerome R. Steen, director of quality control for Sylvania Electric Products

DR. WARD HARRISON, engineering consultant, and past director of engineering for General Electric's Lamp Department, Nela Park, Cleveland, was recipient of the Cleveland Technical Societies Council's annual Distinguished Service Award at the Council's fourth annual banquet on January 30. Dr. Harrison, left, here is being congratulated by James L. Myers, president of the Cleveland Graphite Bronze Co., who made the presentation. Joseph E. Wilhelm, Council president, displays the citation.

Inc., has been elected to grade of Fellow by the board of directors of the Institute of Radio Engineers. He received a Fellowship Award for his work "in the introduction and development of statistical quality control techniques in electron tube manufacturing" during the Institute's National Convention in New York on March 8.

Managers of four newly-created sales divisions within the Southeastern District of Westinghouse have been announced. They are: Florida Sales Division — **Emory L. Puckett**, with headquarters in Tampa, Florida. Carolina Sales Division — **W. R. McKinney**, Charlotte, N. C. South Central Sales Division — **Joseph J. Sanders**, New Orleans. Mid South Sales Division — **R. D. Barr**, Chamblee, Georgia.

Frank L. Taylor has been appointed manager of a newly-created Midwest Lamp Sales Division for Westinghouse lamps, with headquarters in Kansas City, Mo.

Dr. Albert W. Hull, of the General Electric Research Laboratory, who has been credited with the invention of more types of electron tubes than any other man, has retired from his post as assistant director of the laboratory. Dr. Hull will continue to serve the laboratory as a consultant.

Dr. Gorton R. Fonda, of the General Electric Research Laboratory, Schenectady, who with his associates developed the American version of the radar screen, has retired after nearly 40 years service.

Dr. Irving Langmuir, world-famous scientist, retired at the beginning of the year from the General Electric Co., Schenectady. Dr. Langmuir, who has been associate director of the company's Research Laboratory, will continue work in the laboratory in a consulting capacity. He will engage primarily in activities of Project Cirrus, joint weather research program of the U. S. Army Signal Corps and the Office of Naval Research in consultation with General Electric.

Appointment of **Walter A. Toly** as President of the Columbia Electric & Manufacturing Co., Spokane, Washington, has been announced.

Announcement has been made of the formation of a new lighting company, named the Court Butler Lighting Inc., of Stamford, Conn. **L. C. Butler** has been named President of the new corporation, and **Bolton Wilder**, vice-president. **Domenic Guarina** is designer.

Karl Lertsman of Hollywood, California, has been named electrical wholesaling representative for General Lighting Company, for the Southern California area.

Unloading Coal by Fluorescent Light—First Outdoor Installation at a Power Station

Under this title, an article under the signature of G. V. Harrap (Gravesend District Manager, Southeastern Electricity Board) appeared on pages 229-31 of the August 5, 1949 issue of *Electrical Review*, London.

The following excerpts are quoted:

Gravesend scores three "firsts" in the use of outdoor fluorescent lighting. The installation was the first in Great Britain for handling coal, the first for illuminating a quayside, and the first at any power station in the world, as far as can be ascertained from published data. The units described were commissioned in September, 1947, and operating experience has left no doubt about their value.

Coal is received at the Gravesend Power station . . . in barges which are moored to the quayside, and it is lifted by cranes into hoppers from which it is discharged into trucks . . . the quayside lighting (originally) was by an incandescent lamp cluster on the crane jib, although unloading was done only in daylight . . . To meet the requirements of a second crane, and operating hours prolonged into the night, an installation of fluorescent luminaires was decided upon after some experimentation with incandescent lamp clusters variously located.

Hollow steel columns, 32 feet long, were mounted four feet from the water's edge, with a long bracket for the lamp to light the barges . . . the brackets are 9 feet 3 inches long, and can be rotated on the column so as to clean the lanterns from a power wagon on the quay roadway. The three lanterns are 5-foot "daylight" 80-watt units in a housing having a "Perspex" outer cover. . . .

Two fluorescent lighting standards were installed 150 feet apart at the outer limits of the crane jib operating areas. It was not possible to erect a lighting column between the cranes because . . . the cranes travel back and forth on their tracks and there is not space enough to allow for the erection of a column clear of the new crane cab.

The illumination inside the barges with the 150-foot spacing is exceedingly good . . . the color of the coal is reasonably natural and the men have added confidence during work on the barges. There is no doubt that the use of fluorescent lighting has not only been worthwhile but has produced better results than other types. . .

NEW MEMBERS

At the meeting of the Council held February 8, 1949 in New York, the following were elected to membership:

ALAMO CHAPTER

Associate Member:
Uhr, M. H., 302 E. Josephine St., San Antonio, Texas

BRITISH COLUMBIA SECTION

Associate Members:
Bemister, R., Van Horne Electric Supply Co., Vancouver, B. C., Canada
Bodel, J. N., 4318 W. 2nd Ave., Vancouver, B. C., Canada
Durward, R. G., Van Horne Electric Supply Co., Ltd., Vancouver, B. C., Canada
Stobart, Thomas, Electrical Industries Ltd., Vancouver, B. C., Canada

CAPITAL SECTION

Members:
Long, G. A., Jr., Dept. of the Navy, Bureau of Aeronautics, Washington, D. C.
Projector, T. H., National Bureau of Standards, Washington, D. C.

Associate Members:
Jordan, A. B., National Bureau of Standards, Washington, D. C.
Hayes, W. E., Russell Hayes, Inc., Washington, D. C.
Nimeroff, Isadore, National Bureau of Standards, Washington, D. C.

CAROLINAS CHAPTER

Member:
Lang, Gideon L., Jr., Dr., Hugh Grey Hosiery Co., Concord, N. C.

Associate Members:
Harrelson, H. F., Graybar Electric Co., Inc., Charlotte, N. C.
Phelps, L. H., Graybar Electric Co., Inc., Charlotte, N. C.

CENTRAL NEW YORK CHAPTER

Associate Members:
Dorman, W. H., Corning Glass Works, Corning, N. Y.
Glavy, J. H., Lamp Dept., General Electric Co., Syracuse, N. Y.

CHICAGO SECTION

Associate Members:
Bieger, L. D., Public Service Co. of Northern Illinois, Maywood, Ill.
Bonny, F. G., Bonny Electric Supply Co., Forest Park, Ill.
Donaldson, H. W., McArthur Electric Co., Chicago, Ill.
Solomon, L. H., Mitchell Mfg. Co., Chicago, Ill.
Zucker, A. S., Mitchell Mfg. Co., Chicago, Ill.

Student Member:
Marks, Gerald, University of Illinois, Urbana, Ill.

CLEVELAND SECTION

Members:
Eastman, A. A., Lamp Dept., General Electric Co., Nela Park, Cleveland, Ohio
Lash, J. D., Lamp Dept., General Electric Co., Nela Park, Cleveland, Ohio

Associate Members:
Hubble, G. P., Lustra Corp. of America, Brooklyn, N. Y.
Schmidt, P. S., Jr., Lamp Dept., General Electric Co., Nela Park, East Cleveland, Ohio

(Continued on page 15A)

SUSTAINING MEMBERS

Acme Electric Corp.
Cuba, N. Y. *J. A. Comstock*

Admiral Lamp Manufacturing Corp.
3430 So. Ashland Ave., Chicago, Ill. *F. Schwartz*

Advance Transformer Co.
1122 W. Catalpa Ave., Chicago 40, Ill. *Hirsch Epstein*

Alabama Power Co.
Birmingham, Ala. *George L. Morris*

All Bright Electric Products Co.
3017-25 N. Kedzie Ave., Chicago 18, Ill. *Max Klein*

Aluminum Company of America
Gulf Building, Pittsburgh 19, Pa. *C. Braglio*

Amalgamated Electric Corp., Ltd.
984 Pape Ave., Toronto, Ont., Canada *D. W. Patterson*

American Concrete Corp.
4727 North Lamon Ave., Chicago 30, Ill. *J. W. Lewis*

American Fluorescent Corp.
5407 Broadway, Chicago, Ill. *William Ruenzi*

American Sterilizer Co.
Erie, Pa. *Horace Wm. Alexander*

Appleton Electric Co.
1701-1799 Wellington Ave., Chicago 13, Ill. *Nils A. Tornblom*

Arkansas Power & Light Co.
Simmons National Bldg., Pine Bluff, Ark. *Max Huddath*

The Art Metal Co.
1814 E. 40th St., Cleveland 3, Ohio *George E. Glatthar*

Artistic Lamp Manufacturing Co., Inc.
996 Fourth Ave., New York 16, N. Y. *Myron Perlmutter*

Bausch & Lomb Optical Co.
Rochester 2, N. Y. *David L. Williams*

Benjamin Electric Mfg. Co.
Des Plaines, Ill. *John H. Waterbury*

Blue Ridge Glass Corp.
P.O. Box 631, Kingsport, Tenn. *James Herbert*

Board of Water and Electric Light Commissioners
116 W. Ottawa St., P.O. Box 570, Lansing 3, Mich. *John D. Mainright*

Boston Edison Co.
39 Boylston St., Boston 12, Mass. *R. B. Brown, Jr.*

Branham, Mareck & Duepner, Inc.
7020 Walker St., St. Louis Park, Minneapolis 16, Minn. *Cecil H. Branham*

Bright Light Reflector Co., Inc.
Fairfield & State, Bridgeport 5, Conn. *C. E. Schell*

British Columbia Electric Rwy. Co., Ltd.
570 Dunsmuir St., Vancouver, B. C., Canada *H. N. Walters*

Brockton Edison Co.
36 Main St., Brockton 67, Mass. *W. A. Forbush*

Buffalo Niagara Elec. Corp.
Buffalo 3, N. Y. *Jack F. Parsons*

Edward F. Caldwell & Co., Inc.
101 Park Ave., New York 17, N. Y. *E. F. Caldwell*

California Electric Power Co.
P.O. Box 812, Riverside, Calif. *W. E. Vaughn, Jr.*
Ralph G. Raymond

Cal-Lite, Inc.
12600 S. Yukon Ave., Hawthorne, Calif. *N. L. Ureles*

Calpa Products Co.
4116 Chester Ave., Philadelphia 4, Pa. *Paul C. Calisti*

Cambridge Electric Light Co.
45 Blackstone St., Cambridge 39, Mass. *Reginald H. Bowman*

Canadian General Elec. Co., Ltd.
212 King St., Toronto, Ont. *E. M. Love*

Canadian Laco Lamps, Ltd.
745 Guy St., Montreal, Que. *J. Thomas*

Canadian Line Materials, Ltd.
Postal Station H, Toronto 13, Ont., Canada *L. E. Messinger*

Central Hudson Gas and Elec. Corp.
50 Market St., Poughkeepsie, N. Y. *H. E. Dexter*

Central Illinois Light Co.
316 Jefferson Ave. S., Peoria 2, Ill. *R. K. Dallas*

Central Illinois Public Service Co.
607 E. Adams St., Springfield, Ill. *B. L. Palm*

Central Maine Power Co.
9 Green St., Augusta, Maine *Roland W. Hess*

Central New York Power Corp.
300 Erie Boulevard W., Syracuse, N. Y. *L. D. McCormac*

Central Power & Light Co.
P.O. Box 2121, Corpus Christi, Texas *James M. Williams*

Champion Lamp Works Div. of Consolidated Electric Lamp Co.
600 Broad St., Lynn, Mass. *Ellery H. Raddin*

Cincinnati Gas & Electric Co.
Fourth & Main Sts., Cincinnati 1, Ohio *J. R. Hartman*

Circlite Corp.
118 So. Clinton St., Chicago, Ill. *George Gomberg*

City of Burbank, California Public Service Department
174 W. Magnolia Boulevard, Burbank, Calif. *J. H. McCambridge*

City of Glendale Public Service Dept.
119 N. Glendale Ave., Glendale 6, Calif. *H. E. Gulick*

City of Riverside Electric Light Dept.
3854 Mulberry St., Riverside, Calif. *L. W. Grayson*

City of Seattle, Dept. of Lighting — Puget Sound
1015 Third Ave., Seattle 4, Wash. *P. C. Spowart*

City of Tacoma, Light Division
Tacoma 2, Wash. *Ray H. Weston*

The Cleveland Electric Illuminating Co.
72 Public Square, Cleveland 1, Ohio *E. C. Hienton*

Colonial Electric Products Co., Inc.
1115 Market St., E. Paterson, N. J. *Wallace M. Woodworth*

Colonial Premier Co.
466 W. Superior St., Chicago 10, Ill. *Richard Weis*

Columbia Electric & Mfg. Co.
1024 West Ide Ave, Spokane, Wash. *Walter A. Toly*

Commercial Light Co.
841 W. Washington Blvd., Chicago, Ill. *Michael R. Fino*

Commonwealth Edison Co.
72 W. Adams St., Chicago 90, Ill.

The Connecticut Light & Power Co.
250 Freight St., Waterbury 91, Conn.

Consolidated Edison Co. of N. Y., Inc.
4 Irving Place, New York 3, N. Y. *Clarence Law*

Consolidated Gas, Elec. Light & Power Co. of Baltimore
100 W. Lexington St., Baltimore 1, Md. *M. C. Albrittain*

Consumers Power Co.
212 Michigan Ave. W., Jackson, Mich. *D. E. Karn*

Consumers Public Power Co.
1452-25th Ave., Columbus, Nebraska *W. H. Stake*

Corning Glass Works
Corning, N. Y. *A. S. Tyler*

Coyne Electrical School, Inc.
500 So. Paulina St., Chicago 7, Ill. *John Hanan*

Crescent Electric Supply Co.
768 Iowa St., Dubuque, Iowa *Titus B. Schmid*

Crouse-Hinds Co.
Syracuse 1, N. Y. *A. H. Clarke*

Crouse-Hinds Co. of Canada, Ltd.
7 Labatt Ave., Toronto, Ont. *F. R. Jeffery*

Curtis Lighting, Inc.
6135 W. 65th St., Clearing Station, Chicago 38, Ill. *Darwin Curtis*

Curtis Lighting of Canada, Ltd.
195 Wicksteed Ave., Leaside, Toronto 19, Ont. *H. L. Wright*

Cutler Light Manufacturing Co.
2026-28 N. 22d St., Philadelphia 21, Pa. *Robert T. Cutler*

Dallas Power & Light Co.
1506 Commerce St., Dallas 1, Texas *W. G. Moore*

Day-Brite Lighting, Inc.
5401 Bulwer St., St. Louis 7, Mo. *D. J. Biller*

The Dayton Power & Light Co.
25 No. Main St., Dayton, Ohio *H. S. Newsman*

Dazor Manufacturing Corp.
4463 Duncan Ave., St. Louis 10, Mo. *P. L. Read*

Delaware Power & Light Co.
600 Market St., Wilmington 99, Del. *W. A. F. Pyle*

Dept. of Water & Power, City of Los Angeles, Bur. of Power & Light
Box 3669 Terminal Annex, 207 So. Broadway, Los Angeles 54, Calif. *C. P. Garman*

Detroit Edison Co.
2000 Second Ave., Detroit 26, Mich. *L. E. Taylor*

Detroit Steel Products Co.
2250 E. Grand Blvd., Detroit 11, Mich. *W. Clifton Randall*

E. I. duPont de Nemours & Co., Inc. (Fabrics & Finishes Div.)
Wilmington 98, Del. *E. W. Quisenberry*

E. I. du Pont de Nemours & Co., Inc. Polychemicals Dept.
Wilmington 98, Del. *E. F. Leary*

Duquesne Light Co.
435 Sixth Ave., Pittsburgh 19, Pa. *G. W. Ousler*

Duro Test Corp.
3321 Hudson Blvd., North Bergen, N. J. *James L. Cox*

Eastern Fixture Co., Inc.
170 Vernon St., Boston 20, Mass. *Louis Gilman*

(*Note:* Names of Official Representatives appear in Italics)

East Side Metal Spinning & Stamping Corp.
1 W. 24th St., New York 1, N. Y.
M. A. Kremer

Ebasco Services, Inc.
2 Rector St., New York 6, N. Y.
P. D. Brooks

Electrical Information Publications, Inc.
20 E. Mifflin, P.O. Box 282, Madison, Wis.
W. N. Dudley

Electrical Testing Laboratories, Inc.
79th St. & East End Ave., New York City 21, N. Y.
Preston S. Millar

Elec. Service Mfg. Co.
17th & Cambria Sts., Philadelphia 32, Pa.
E. A. Leinroth

Electro Manufacturing Corp.
3000 W. Fulton St., Chicago 12, Ill.
L. K. Schoenbrod

Electrolier Mfg. Company, Ltd.
5849 Boyer St., Montreal, Que., Canada.
John Isserman

Ender Manufacturing Corp.
360 West St., New York 13, N. Y.
Jules Levenstein

Electron Corp.
4501 Galapago, Denver, Colo. *Floyd Vickers*

Englewood Electrical Supply Co.
5801-03 So. Halsted St., Chicago, Ill.
Ray O'Leary

Famous Fluorescent Light Co.
762 N. Ogden Ave., Chicago 22, Ill.
Jack R. Stone

Federal Electric Company, Inc.
8700 S. State St., Chicago, Ill.
John H. Goshst

Fitchburg Gas & Electric Light Co.
537 Main St., Fitchburg, Mass. *A. G. Neal*

Fluorescent Equipment & Mfg. Co.
2570 Superior Ave., Cleveland 14, Ohio
Leonard E. Freeman

Fluorescent Maintenance Co., Inc.
1480 S. Robertson Blvd., Los Angeles 35, Calif. *Leonard K. Black*

Fluores-O-Lite Co.
Evans Terminal, No. Broad St., Hillside, N. J.
Meyer H. Silverman

The Fostoria Pressed Steel Corp.
Fostoria, Ohio *E. L. Bates*

H. A. Framburg & Co.
3320-28 Carroll Ave., Chicago 24, Ill.
Stanley A. Framburg

The France Mfg. Co.
10325 Berea Rd., Cleveland 2, Ohio
J. H. Mayne

The Frankelite Co.
1425 Rockwell Ave., Cleveland 14, Ohio
Dave Frankel

Franklin Design Service, Division of Safeway Stores, Inc.
4th & Jackson Sts., P.O. Box 660, Oakland 4,
Wallace H. Lane

The Frink Corporation
27-01 Bridge Plaza North, Long Island City, N. Y. *Theo. J. Brussel, Jr.*

Gallagher-O'Brien Electric Co., Inc.
712 N. State St., Chicago 10, Ill.
Frank A. Gallagher

Garden City Plating & Mfg. Co.
1750 No. Ashland Ave., Chicago 22, Ill.
G. G. Harney

General Electric Co., Apparatus Dept.
River Works, 920 Western Ave.,
West Lynn, Mass. *A. F. Dickerson*

General Electric Co., Lamp Dept.
Nela Park, Cleveland 12, Ohio
Willard C. Brown

General Electric Supply Corp.
1260 Boston Ave., Bridgeport, Conn.
W. W. Booth

General Lighting Products Co.
468 Frelinghuysen Ave., Newark 5, N. J.
Nathan H. Eglowstein

General Outdoor Advertising Co., Inc.
515 So. Loomis St., Chicago, Ill. *R. E. Nevins*

The Georgia Power Co.
Electric Building, Atlanta 1, Ga.
Charles A. Collier

Gibson Manufacturing Co.
1919 Piedmont Circle, N. E., Atlanta, Ga.
R. R. Gibson

Gill Glass & Fixture Co.
Amber & Tioga Sts., Philadelphia 34, Pa.
C. A. Gill

Gillinder Brothers, Inc.
Erie & Liberty Sts., Port Jervis, N. Y.
J. Fletcher Gillinder

Gleason-Tiebout Glass Co.
59-50 54th St., Maspeth, N. Y.
Charles W. Gleason

Globe Lighting Products Co., Inc.
397 Seventh Ave., Brooklyn, N. Y.
Isidor Rosenblatt

Golde Manufacturing Co.
1214 West Madison, Chicago 7, Ill.
E. W. Goldberg

Grand Rapids Store Equip. Co.
1340 Monroe Ave., N. W., Grand Rapids 3, Mich. *Kenneth C. Welch*

Graybar Electric Co., Inc.
420 Lexington Ave., New York 17, N. Y.
Raymond C. Kinney

Gulf States Utilities Co.
Box 2951, Beaumont, Texas *Clarence Barron*

The Edwin F. Guth Co.
2615 Washington Ave., St. Louis 3, Mo.
Fred E. Guth

The Hankins Container Co.
3044 W. 106th St., Cleveland 11, Ohio
Ray T. White

Hartford Electric Light Co.
266 Pearl St., Hartford 3, Conn.
Victor Ouellette

Hawkins Electric Co.
1447 Washington Blvd., Chicago 7, Ill.
R. R. Hill

Hendrickson-Hofferman Co., Inc.
45-17 Pearson St., Long Island City 1, N. Y.
Joseph T. Manuccia

Holdenline Co.
3301 Scranton Rd., Cleveland 13, Ohio
H. E. Ingraham

Holophane Company, Inc.
342 Madison Ave., New York 17, N. Y.
H. L. Logan

Home Gas & Electric Co.
810 Ninth St., Greeley, Colo.
C. Gilbert Dresser

Houston Lighting & Power Co.
P.O. Box 1700, Houston 1, Texas
H. G. Clarke

Hydro-Electric Power Comm. of Ont.
620 University Ave., Toronto, Ontario.
R. L. Hearn

Hyland Electrical Supply Co.
700 West Jackson Blvd., Chicago, Ill.
Chas. H. Weisenborn

Illinois Power Co.
134 East Main St., (L Box 511 B), Decatur 70, Ill. *Allen Van Wyck*

Illuminating Engineering Co.
2347 E. Nine Mile Road, Hazel Park, Mich.
Bert C. Pretzer

Iowa-Illinois Gas & Electric Co.
United Light Bldg., Davenport, Iowa
John M. Hollingsworth

Iowa Public Service Co.
400 Commercial St., Waterloo, Iowa
C. E. Wagener

Jeannette Shade & Novelty Co.
N. Fourth St., Jeannette, Pa. *H. N. Creek*

Jefferson Electric Co.
Bellwood, Ill. *L. Meserve*

Jersey Central Power & Light Co.
501 Grand Ave., Asbury Park, N. J.
D. J. Douglas

Joleco Corporation
2513 Baldwin St., St. Louis, Mo.
George Ledbetter

Jones Metal Products Co.
West Lafayette, Ohio *H. Boyer*

Joslyn Mfg. & Supply Co.
3700 So. Morgan St., Chicago 9, Ill.
J. H. Fahey

Kahn Manufacturing Co., Inc.
2051 N. 19th St., Milwaukee, Wis.
Charles F. Kahn

Kansas City Power & Light Co.
P.O. Box 679, Kansas City 10, Mo.
John M. Arthur, Jr.

Kansas Gas & Electric Co.
P.O. Box 204, Wichita, Kans. *H. W. Hobson*

The Kawneer Co.
North Front St., Niles, Mich.
Richard M. Spray

The Kayline Company
2480 E. 22nd St., Cleveland 15, Ohio
M. A. Eskine

Kelso-Burnett Electric Co.
223 W. Jackson Blvd., Chicago 6, Ill.
Sigmund A. Hollingsw

Keystone Electric Manufacturing Co.
2328-36 E. Tioga St., Philadelphia 34, Pa.
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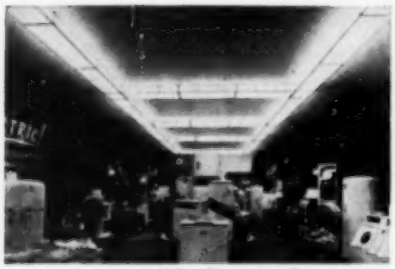

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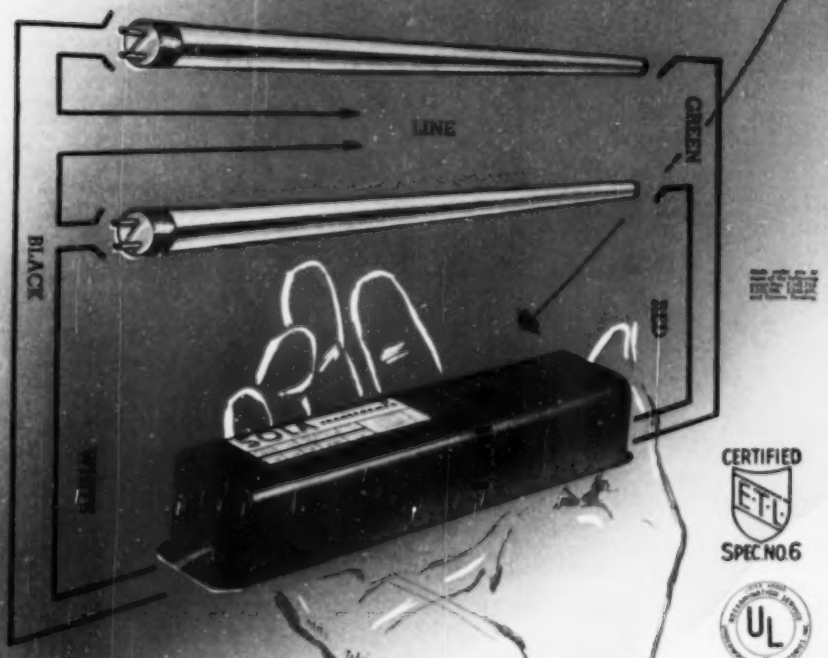

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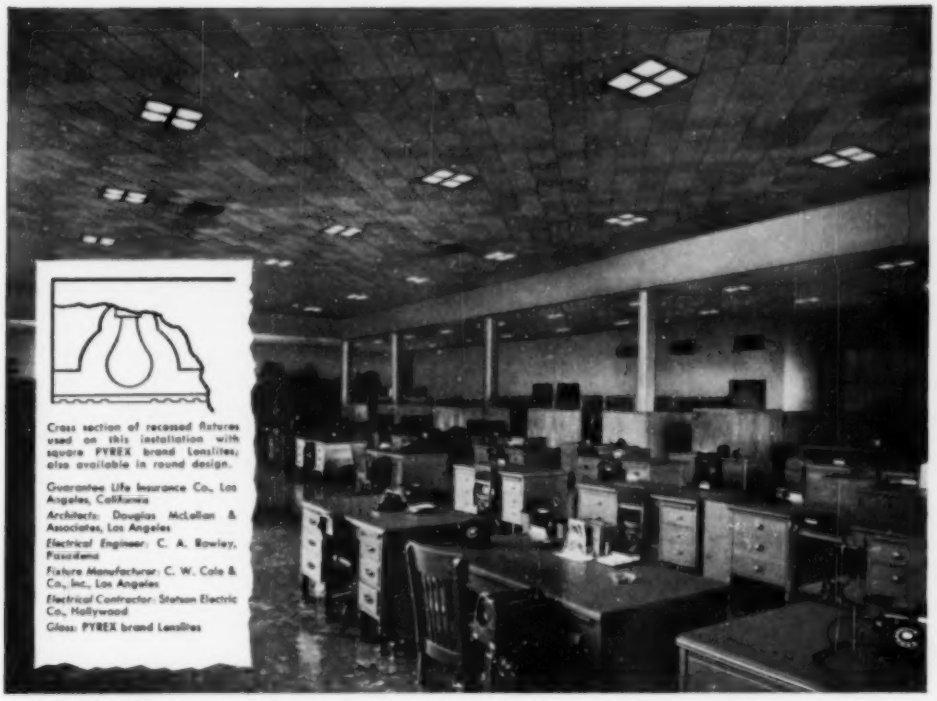
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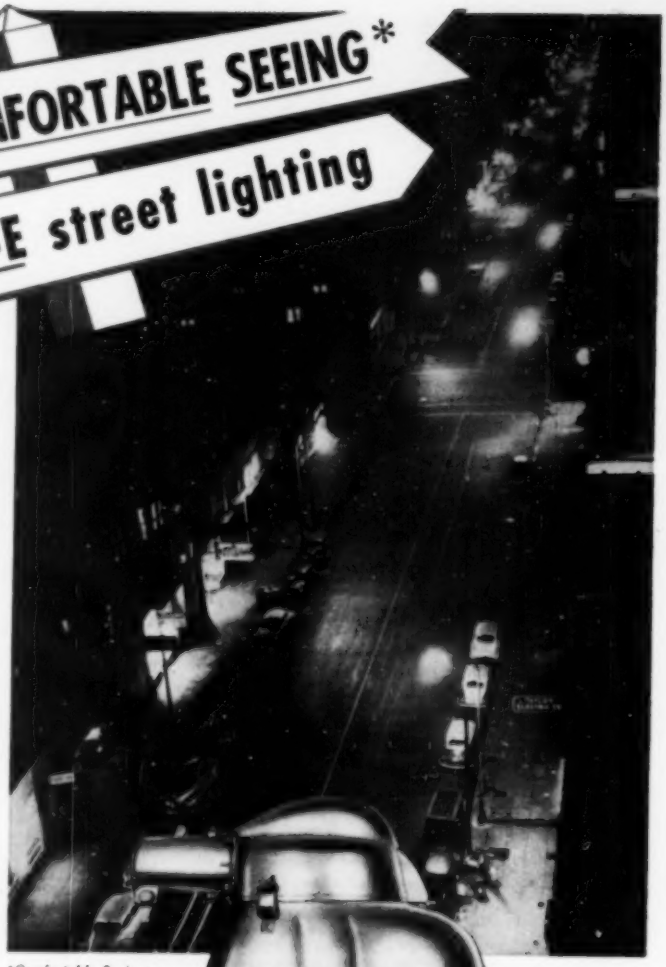
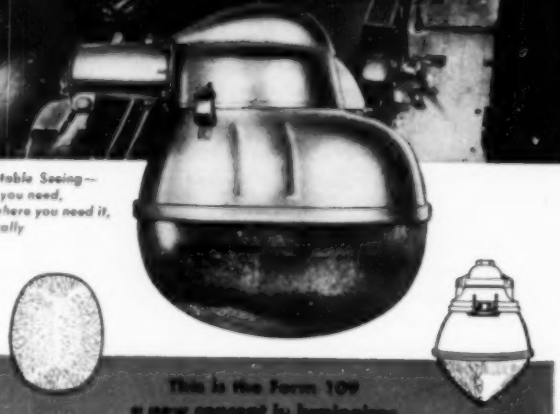


For Comfortable Seeing along principal traffic routes, take a look at Seattle, Washington. Here as part of a gigantic safety program, 223½ miles of streets were relighted last year, almost 50 more will be relighted this year. The ultimate plan is to have new lighting on 330 miles of arterials. All of this new lighting will be mercury-vapor—with its high efficiency (more than twice as much light per watt as filament lamps), and its crisp, distinctive color. All lighting levels will at least equal American Standard Practice.

As part of this program, General Electric is currently shipping a large quantity of Form 109 luminaires to Seattle. These units are exceptionally effective in directing light onto the street. With proper spacing and mounting height, they provide a remarkably uniform pavement brightness. Their excellent shielding and large apparent light source hold glare to a minimum. And the same luminaire will burn 11,200-, 16,000- or 21,000-lumen lamps—horizontally as well as vertically at full expected life. (It will also burn large filament lamps increasing further the flexibility and the possibilities of standardization.)

When you plan relighting of traffic arteries get the details on this modern, versatile mercury luminaire. It will help provide Comfortable Seeing for your community, too. Write *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

*Comfortable Seeing—*the light you need, exactly where you need it, economically*



This is the Form 109
a new concept in luminaires

Notice the new and exclusive ovoid triple-lateral reflector and streamlined refractor. These new design features, scientifically balanced against each other, develop new standards for utilization, distribution and glare control.

GENERAL ELECTRIC

452-101

HOW TO UTILIZE THE SYLVANIA "FLEXI-MODULE" LIGHTING SYSTEM

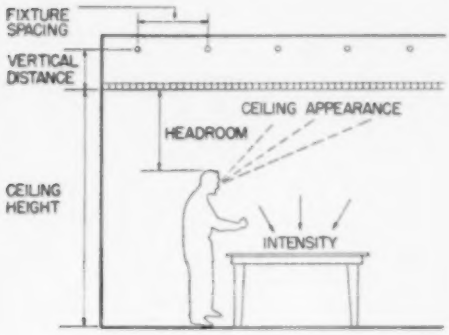
PART 2

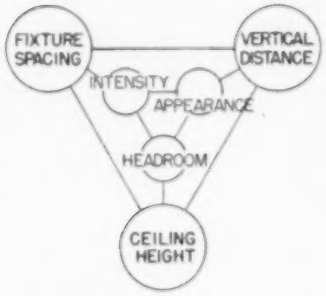
Fundamental Relationships

In the design of a Sylvania "Flexi-Module" System installation, it is necessary to take three factors into account: the intensity of illumination desired; the appearance of the ceiling (whether it is to be evenly or unevenly lighted); and the headroom in the finished room.

These factors are determined by three relationships:

1. *Spacing between fixtures.*
2. *Vertical distance between grid and fixtures.*
3. *Height of grid above floor.*



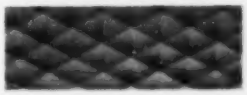


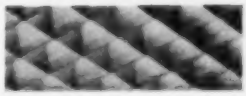
The diagram indicates the interdependence of these factors. It will be apparent that in installations in existing spaces, it may sometimes be necessary to effect a compromise among the desired factors. For a given intensity of illumination and ceiling appearance, the headroom is automatically determined. If this headroom is inadequate, it may be advisable to design for uneven ceiling brightness instead of even.

Lighting Intensities

The intensity required for a specific installation will of course be determined by the illuminating engineer. The Sylvania "Flexi-Module" Ceiling is equally adaptable to low or high intensities. Its low surface brightness and freedom from glare become, of course, increasingly important advantages as the intensity is raised.

Ceiling Appearance





Installations can be designed for either even or uneven surface brightness, depending on the grouping of the fixtures. Where unevenness is desired—as for directional effects—the "Flexi-Module" Ceiling has the advantage of concealing the irregularity in fixture arrangement.

Mail the coupon for complete information on the Sylvania "Flexi-Module" System

Sylvania Electric Products Inc.
Advertising Dept. L-2903
500 Fifth Avenue, New York 18, N. Y.
Gentlemen:
Please send me complete information on the Sylvania "Flexi-Module" Lighting System.

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Company_____

Address_____

City_____ State_____

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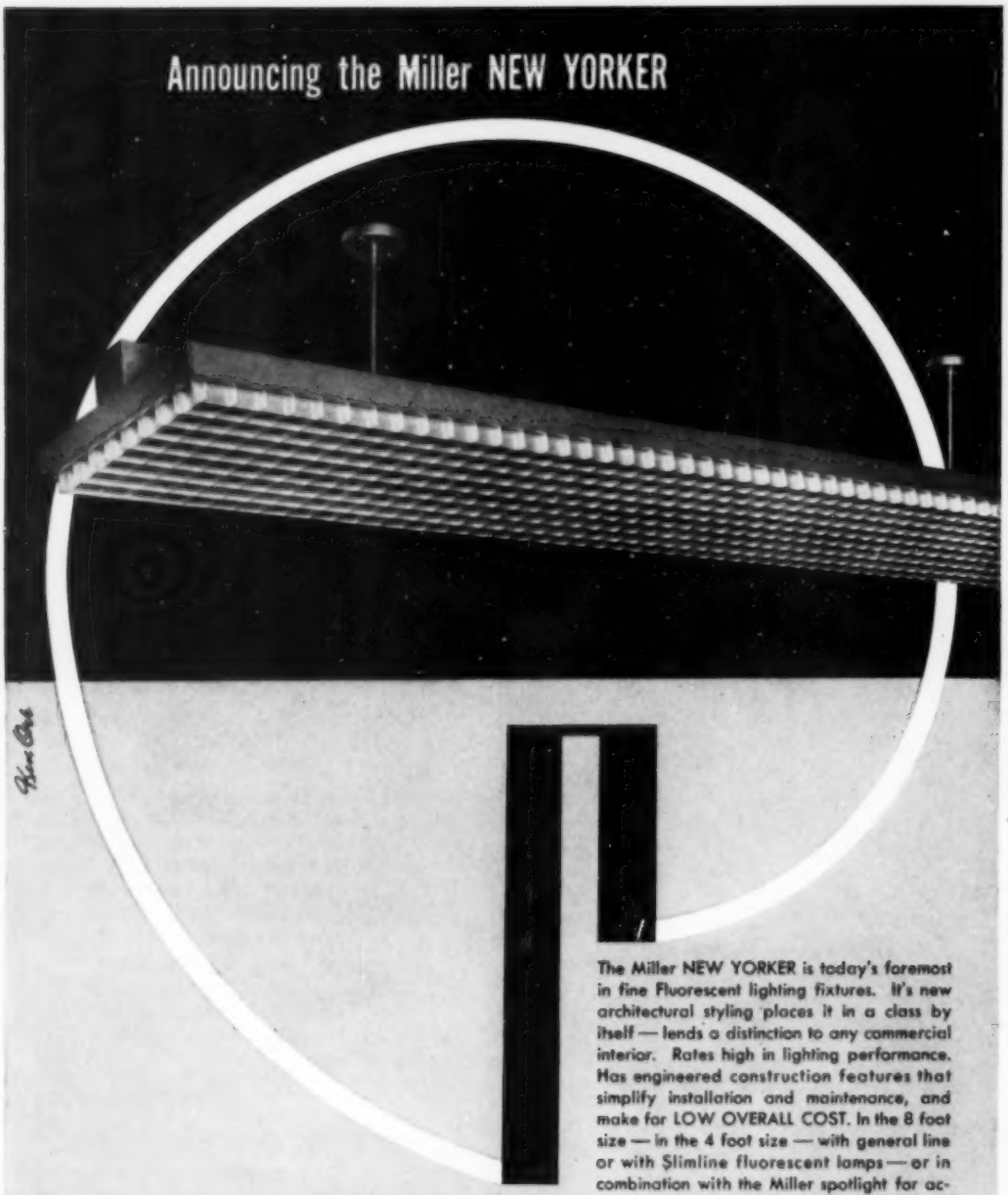
Announcing the Miller NEW YORKER



The Miller NEW YORKER is today's foremost in fine Fluorescent lighting fixtures. It's new architectural styling places it in a class by itself — lends a distinction to any commercial interior. Rates high in lighting performance. Has engineered construction features that simplify installation and maintenance, and make for LOW OVERALL COST. In the 8 foot size — in the 4 foot size — with general line or with Slimline fluorescent lamps — or in combination with the Miller spotlight for accent lighting, it is unquestionably today's finest in fluorescent lighting. Write for the NEW YORKER catalog. Miller engineers and distributors are conveniently located to serve you.

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ILLUMINATING DIVISION: Fluorescent, Incandescent, Mercury Lighting Equipment. HEATING PRODUCTS DIVISION: Domestic Oil Burners and Liquid Fuel Burners. ROLLING MILL DIVISION: Phosphor Bronze and Brass in Sheets, Strips and Rolls

Individual lighting fixtures in this PLEXIGLAS installation measure 6 x 8 feet and consist of four corrugated-bottom diffusing panels with curved side panels—all of white translucent acrylic plastic. Each fixture is lighted with two 96" 300 MA Slimline and two 40-watt fluorescent lamps. Room ceiling is 10 feet high. Fixtures installed by Bell Electric Company. Design Consultants: W. E. Conley, General Electric Company; John Ulam, George S. Rider Co.; W. A. Allen, Cleveland Electric Illuminating Company.

15 Times the Illumination from One-Half the Wattage... with PLEXIGLAS

This is the banking room in Cleveland's Bank of Ohio—before and after PLEXIGLAS lighting was installed. Lighting-level averages have increased from 4 footcandles to 62 footcandles on the working surfaces—with a 50% decrease in wattage. Under these improved conditions it's not surprising that bank personnel are more cheerful, alert and efficient.

For *Quality Lighting*, ease of installation and low-cost maintenance, architects and illuminating engineers are specifying PLEXIGLAS in banks, offices and public buildings. PLEXIGLAS lighting fixtures diffuse light without absorbing it—transmit *full* illumination without glare. Lightness and strength permit installation with fewer, lighter supports. And resistance to age, weather, breakage and discoloration reduces maintenance charges to a minimum.

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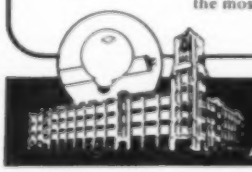

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(*Continued from page 205*)

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(*Continued on page 18A*)

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Acme Electric

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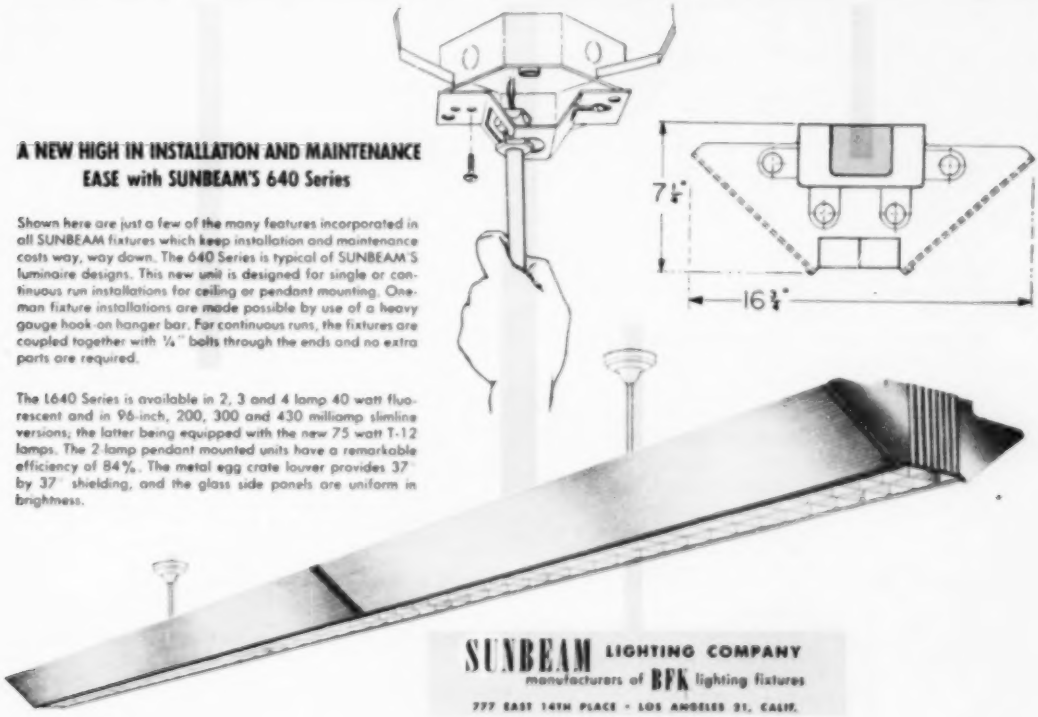
Shown here are just a few of the many features incorporated in all SUNBEAM fixtures which keep installation and maintenance costs way, way down. The 640 Series is typical of SUNBEAM'S luminaire designs. This new unit is designed for single or continuous run installations for ceiling or pendant mounting. One-man fixture installations are made possible by use of a heavy gauge hook-on hanger bar. For continuous runs, the fixtures are coupled together with ¼" bolts through the ends and no extra parts are required.

The L640 Series is available in 2, 3 and 4 lamp 40 watt fluorescent and in 96-inch, 200, 300 and 430 milliamp slimline versions; the latter being equipped with the new 75 watt T-12 lamps. The 2-lamp pendant mounted units have a remarkable efficiency of 84%. The metal egg crate louver provides 37° by 37° shielding, and the glass side panels are uniform in brightness.



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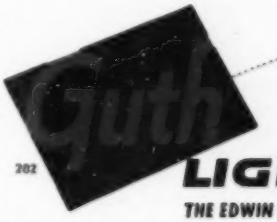

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Certified Ballasts are checked and rechecked in actual service—an additional safeguard for high quality.

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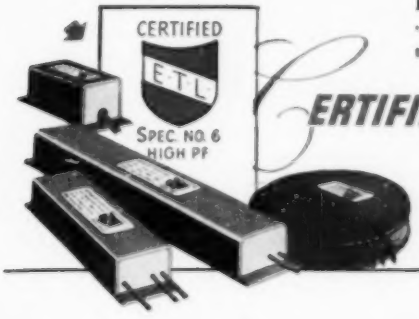

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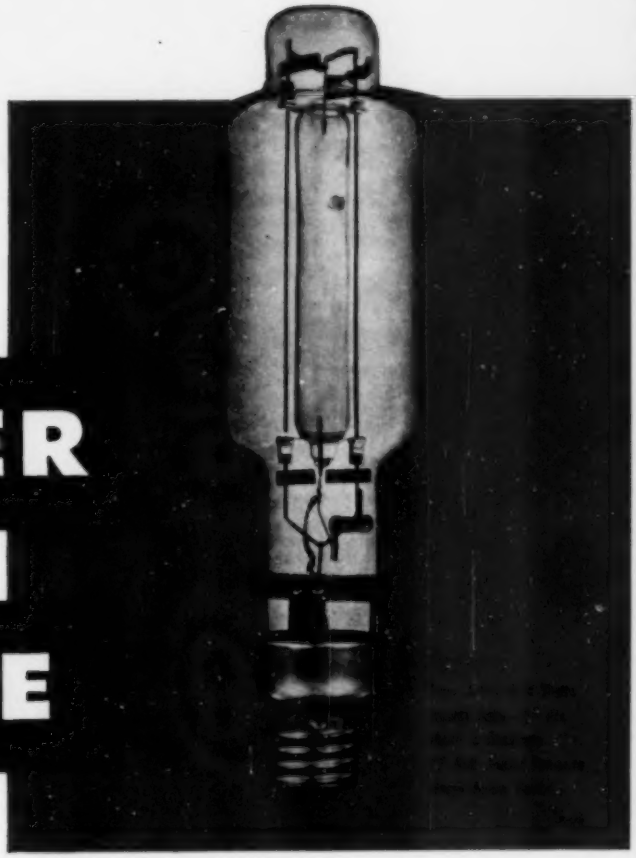

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For more information about the A-H12, or any mercury vapor lamp in the *complete Westinghouse line*, write: Lamp Div., Westinghouse Elec. Corp., Bloomfield, N. J.

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